VOLUME 12 • NUMBER 6 • DECEMBER, 1940

Metals and Alloys

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Published Monthly by Reinhold Publishing Corporation, East Stroudsburg, Pa., U.S.A. Ralph Reinhold, President and Treasurer; H. Burton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President. Executive and Editorial Offices, 330 West 42nd Street, New York. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft). Copyright, 1940, by Reinhold Publishing Corporation. All rights reserved. Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

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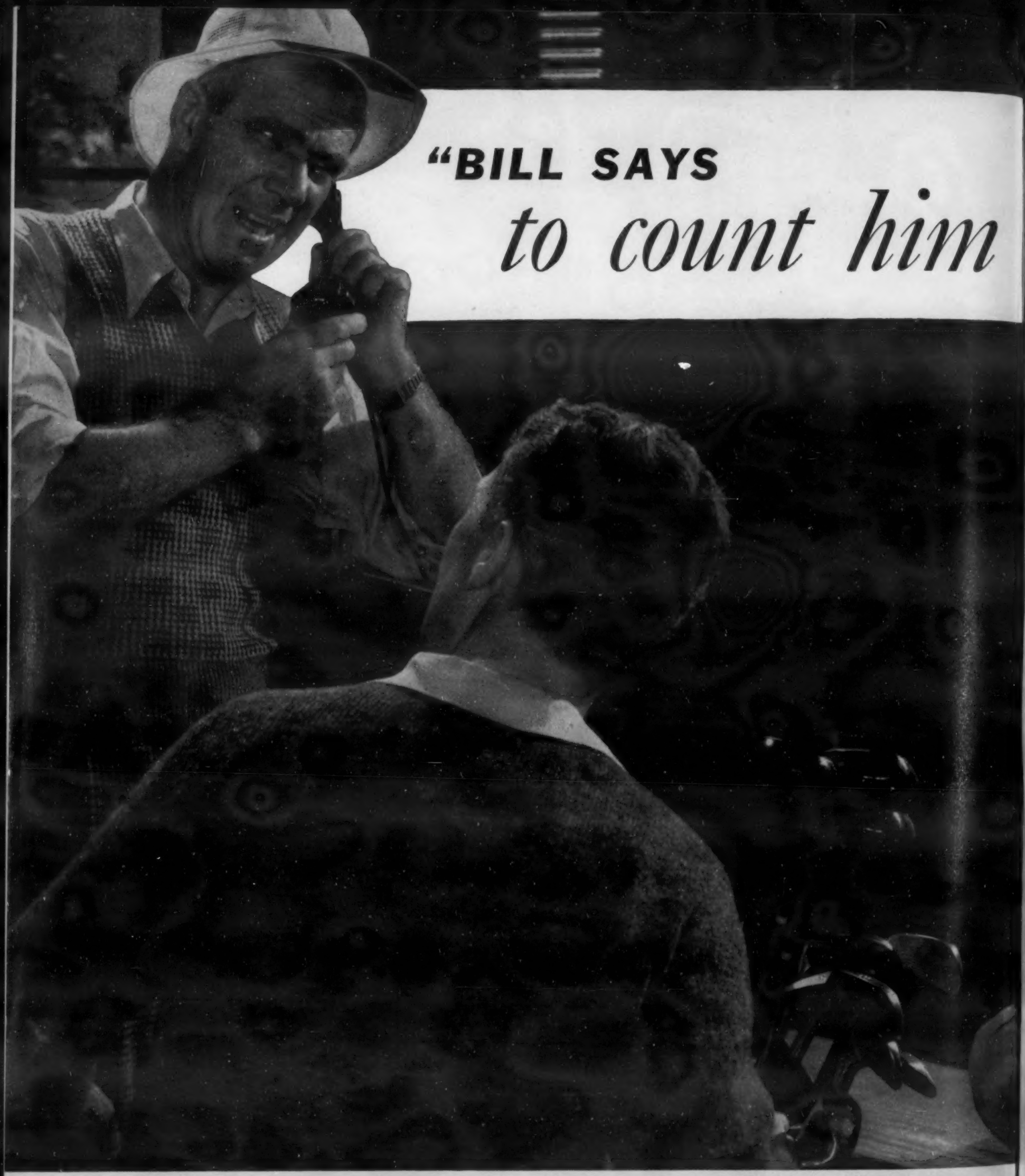

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Feature Section

Metals for the Dairy Industry

A large quantity of metals and their alloys, especially stainless steel, is consumed in the production of equipment for the dairy industry, one which has many ramifications. Dr. Trebler discusses authoritatively the various alloys suitable for certain conditions.

Powder Metallurgy

Mr. Seelig tells the engineer who must design a die and supervise the pressing operation in powder metallurgy practice just how these things should be done.

Metals for Bearings

The extensive and authoritative review of metals for bearings as affected by world war conditions is concluded with this fourth monthly instalment.

Aluminum and Magnesium in Defense

The series of articles on Metallurgical Engineering in Preparedness and Defense, to which the entire October issue was devoted, and which was continued in an abbreviated form in November, is further expanded in this issue.

Two authors discuss the situation as to aluminum and magnesium as affected by the Defense Program.

The Institute's Technical Committees

The technical committees of the American Iron and Steel Institute play an important role whether in peace or war. Their particular relation to the Defense Program is reviewed by the secretary of the Institute's general technical committee.

•

Cerium in Cast Iron

According to Baukloh & Meierling (page 788) cerium increases the fluidity of liquid iron, and enhances the strength and hardness of the cast metal.

Engineering Digests

Die Casting

Production practice for making die castings of zinc alloys and light metals is reviewed in a composite on page 792.

Save the Surface

Protective coatings of a variety of types were discussed in a group of papers at the recent Metal Show, summarized on page 800. Galvanized, tinplate, stainless steel treatments, and coatings on aluminum and magnesium are covered.

Inorganic Pickling Inhibitor

Stannous chloride, say Hoar & Baier (page 815) is an excellent pickling inhibitor for steel (particularly if used with flour or gelatine or cresolsulphonic acid).

What's in a Plane?

Unusually comprehensive data for the design engineer on modern aircraft materials are assembled by Jackman (page 820), who comments *inter alia* on pre-stressing and on strain gages.

Aluminum Bearings

Vaders (page 824) ponders the slow acceptance of aluminum alloy bearings, hints mis-use, and suggests some aluminum-base alloys with manganese or with lead and antimony or with magnesium and zinc.

Deep-Drawing Tests

The Kayseler test for deep-drawability is investigated by Püngel (page 832), who finds it parallels practical experience admirably. Our reviewer, tho' says it's a too tedious test.

NEW G-E Gas-carburizing Furnace Gives You 4 Big Savings

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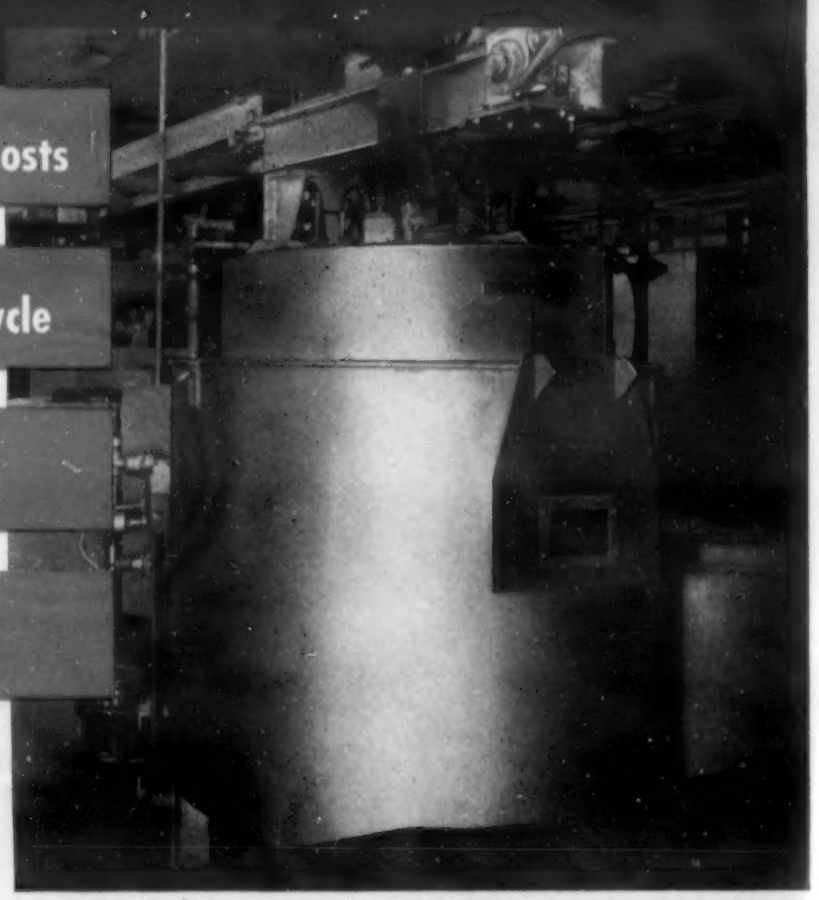
Saves Time by Shortening Carburizing Cycle

Saves By Completely Eliminating Packing

Saves By Doing Highly Uniform Work



A typical installation of a G-E gas-carburizing furnace. Note the controlled-atmosphere cooling chamber at extreme right, also the easy accessibility of the standard induction motor which drives the fan.

REMARKABLE savings are made with this new gas-carburizing, electric furnace. And the reason is very simple. NO PACKING MATERIAL IS USED. This means that considerably less time is required to bring the charge to carburizing temperature; hence, big savings are made in time and power cost. It also means no labor and no expense for packing parts. Work is simply placed in lightweight trays that are economical to use, and it is ready to be put into the furnace.

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This Free Bulletin May Show You How to Save Time and Money

Our new bulletin, GEA-3523, gives complete information about this new gas-carburizing furnace. The G-E office in your region will be glad to give you a copy. Or, write to General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

18:8 and Notched Fatigue

In the case of most alloys under repeated stress, the endurance limit, determined upon smooth, well-filleted specimens, as is the case in laboratory investigations, is merely a par value, indicating the best possible performance when everything is favorable. In actual engineering use, unless extreme precautions are taken to avoid tool marks, grinding scratches, rough welds, sharp fillets, keyways and like stress-raisers, performance is apt to be woefully below the laboratory par. The stronger the alloy is made, by cold working, heat treatment or by choice of composition, the more notch-sensitive it becomes, in the vast majority of cases, so that the notched-endurance limit is relatively little improved, often made worse.

Corrosion-fatigue is perhaps better understood by the engineer; he is less likely to forget that he cannot count on the endurance limit of a smooth bar when he allows it to corrode during the application of repeated stress.

In the case of repeated stress on a notched bar, ordinary carbon and alloy steels, no matter what their heat treatment, can hardly be brought up to a notched endurance, figured on the section at the base of the notch, without correction for stress concentration, of 45,000 lbs. per sq. in. and, in the case of such steels under corrosion fatigue, a usefully long life can hardly be secured at 25,000 lbs. per sq. in. If both deteriorating effects are present and one must use steel under corrosion fatigue conditions and also in the notched condition the repeated stress may have to be reduced very far. Dolan[1] has recorded a case of a stress that gave an endurance limit on a smooth bar in air of 90,000 lbs. per sq. in. but under combined notching and corrosion-fatigue, it fell to 9,000 lbs. per sq. in.

The behavior of strengthened ferritic steels with notches or under corrosion-fatigue is so little improved over that of the normalized condition that relatively little benefit is obtained by cold working or heat treating. Broadly speaking, the common non-ferrous alloys are, similarly, almost as good in the soft condition as when made stronger by one means or another.

In this distressing picture there are a couple of bright spots. Cast iron is relatively notch insensitive, and even under corrosion-fatigue, high test iron of the A.S.T.M. Class 40 appears decidedly better than most engineers have suspected. Of course, even modern cast iron is not going to provide a really strong engineering material for notched-fatigue and corrosion-fatigue service, merely a cheaper one of competitive properties.

The brightest spot is the 18:8 type of steel. That 18:8 should have good corrosion-fatigue behavior would naturally be expected, and, in many corrosive environments, though not in all, this expectation is fulfilled. High fatigue resistance on the basis of un-notched tests is always listed among the virtues of 18:8, and this is especially emphasized by those pushing 18:8 spot-welded assemblies for streamliners and for aircraft construction. The notched-fatigue behavior, on the contrary, has not had the comment it deserves. The producers of 18:8 seem to have been asleep at the switch in not making more clear to the engineer that the material should often be economical for quite prosaic uses, involving stress concentration such as shafts with splines or key ways, or in general, when a designer is so cramped for room that he simply has to inflict a poor radius or sharp corner on the part he is designing.

The engineering fraternity ought to be disabused of the idea that just because 18:8 is nice and shiny and is good for automobile trim, or for some other place where you can see it, that is all it is good for. Russell and Welcker,[2] Brophy[3] and Oberg and Johnson[4] all found that a notched specimen of annealed 18:8 was stronger in fatigue than an unnotched one, due to work hardening of the base of the notch when cutting the notch. Russell and Welcker also showed that 18:8 is remarkably resistant to damage by overstress. Oberg and Johnson showed that 18:8 cold-drawn to 132,500 lbs. per sq. in. tensile, with the usual endurance limit of around 70,000 lbs. per sq. in. for material cold-worked to that degree, had 50,000 lbs. per sq. in. endurance limit with a 60-deg. notch. Hruska[5] reports that the softened weld in hard, cold worked 18:8 sheet, has an endurance limit of 50,000 lbs. per sq. in. Behavior of unnotched specimens in fatigue at —40 deg. F.[6, 7] and at 800-1200 deg. F.[8] was excellent.

There is every indication that not only under most corrosive conditions and under extreme temperature conditions, but also in the presence of stress-raisers, and under overstress, the behavior of 18:8 in endurance is head and shoulders above the best obtainable with ordinary carbon and alloy steels, no matter how heat treated. This is not to say that all 18:8 will behave exactly alike, since the propensity toward work hardening, which seems to be the property most involved in the resistance of notched-fatigue and the average by overstress, is known to vary somewhat within the commercial

(Continued on page 768)

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Metals and Alloys in the Dairy Industry

by H. A. TREBLER

Sealtest, Inc. Research Laboratories, Baltimore, Md.

From time to time we have published articles in a series on the general subject of the "metallurgical needs of the non-metallurgical industries." This is another in that series.

The use of metals and their alloys in the dairy industry is impressive and expansive. Attendance at the national exposition of the American dairy industry in Cleveland about two years ago suggested the feasibility of this article. The Public Auditorium was filled with every possible variety of equipment, predominant among which was several hundred thousand dollars' worth of stainless steel. The whole show was impressive as well in its display of many uses of other metals and their alloys in the dairy industry.

We are fortunate in being able to present a discussion of this subject by a man who has spent many years in close contact with the industry. Dr. Trebler's contribution is both interesting and authoritative.—The Editors.

THE DAIRY INDUSTRY is today definitely living in the stainless steel age, while 10 or 15 years ago it was just as definitely living in the copper age. At that time probably about 90 per cent of all equipment surfaces for direct contact with dairy products were made of copper with or without a tin coating. Today it is probably safe to say that 90 per cent of the same surfaces when replaced or newly constructed are made of 18 and 8 stainless. Possibly the pendulum has now swung too far over and there will be a partial return to materials which were earlier discarded on account of various shortcomings which present development work may overcome.

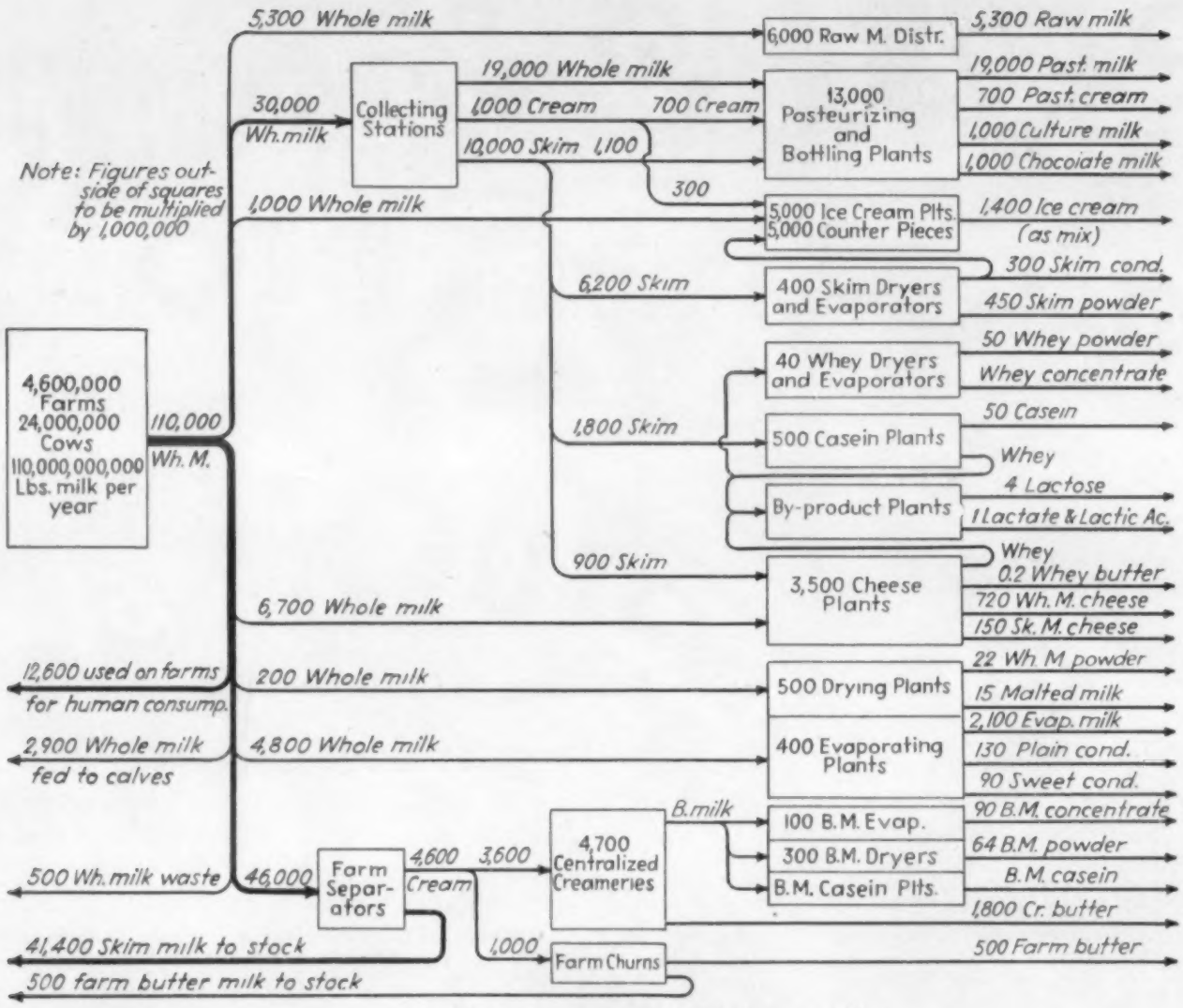
The entrance of stainless steel into the dairy industry has had a tremendous importance as regards manufacturing methods and design of equipment. What at first looked like the most serious shortcoming of 18 and 8 stainless steel, namely, that it was difficult to solder, has actually been of great help to the industry because it has brought about the highly sanitary all welded construction with rounded corners and streamlined design.

Of course, the most used material for general construction of dairy equipment is today, as it has been for a very long time, plain iron or steel with or without protective coatings of tin, zinc, glass, enamel, lacquer and paint; but for new dairy equipment surfaces for direct contact with the products 18 and 8 stainless steel definitely predominates.

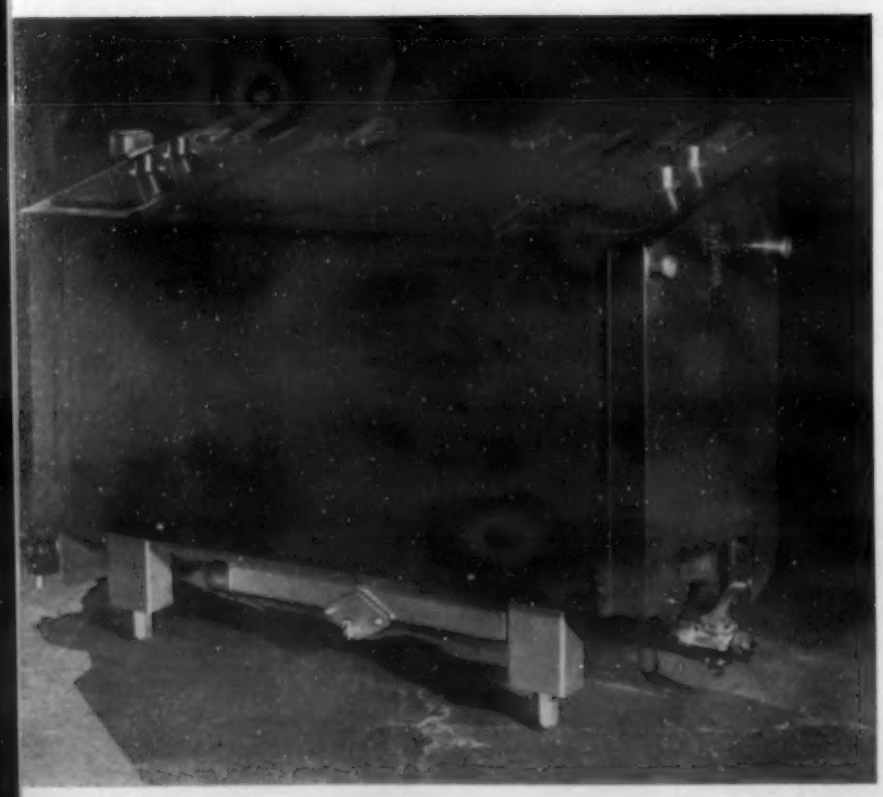
The requirements for the ideal material for construction of dairy equipment surfaces for direct contact with the products has been listed as follows:[1]

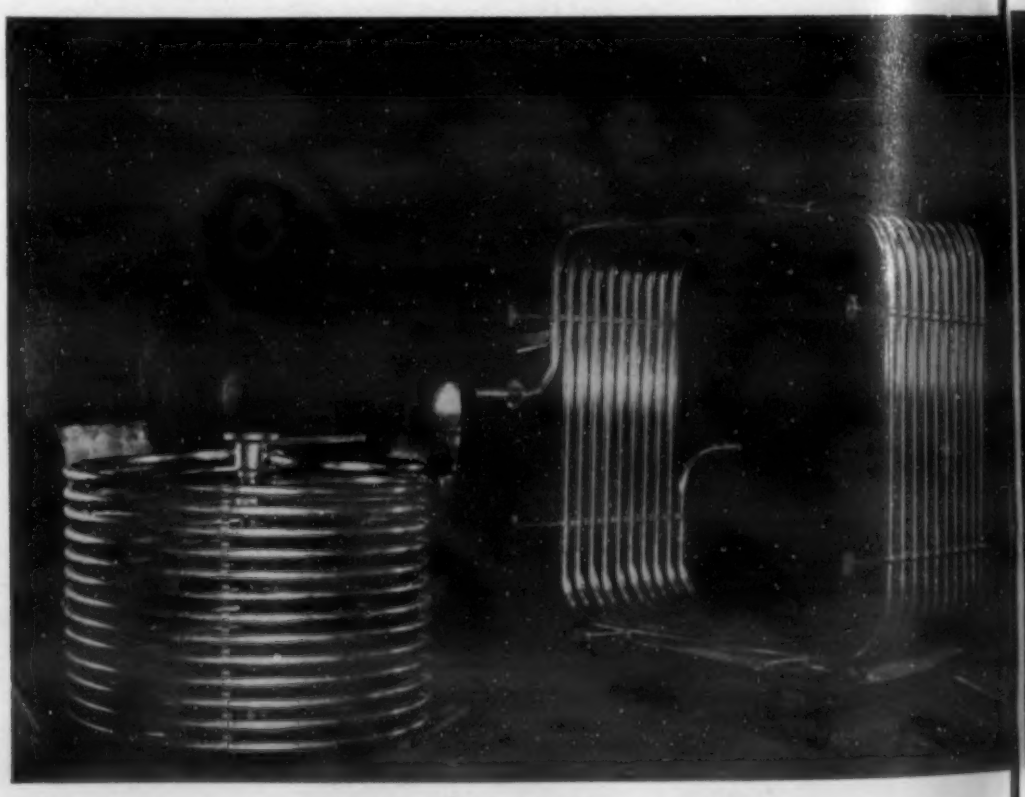
> It should be insoluble in the products under all the various conditions encountered.
>
> It should, furthermore, not be attacked by any kind of water or cleaning or sterilizing solution, nor any kind of cooling medium used in the industry such as ice water, brine, or ammonia.
>
> It should not be toxic, nor have any deleterious effect upon flavor or keeping qualities of dairy products.
>
> It should be easy to clean, look bright, be sufficiently strong to resist pressure, rough usage, and much scrubbing.
>
> In addition this ideal material should, of course, have good heat conductivity, be reasonable in price, and have all the usual mechanical and working properties which are desirable in all equipment construction.

No single material will ever fill this bill. The best to be hoped for is to find the compromise material which will serve best for a particular purpose and then at the same time try to adapt conditions to the material by slight changes in cleaning, sterilizing, heating and cooling practice. The 18 and 8 chrome-nickel-iron alloy (stainless steel) and the 14-80 alloy (Inconel) may come as close to



A flow sheet of the milk industry.





Left: This spray pasteurizer has all stainless, all-welded lining, stainless steel covers and stainless steel veneer as outer finish. The interconnecting sanitary fittings, holding tube, etc. are all of stainless steel pipe with nickel alloy or "Diamond" fittings. (Courtesy: Cherry-Burrell Corp., Little Falls, N. Y.) Right: Coils of Inconel used for contact with buttermilk. Coil at left is for heating and cooling, using water; coil at right is for cooling with circulating brine. Silver soldering used throughout. Built by American Copper and Brass Works, Cincinnati. (Courtesy: International Nickel Co.)

filling the bill as any materials ever will. Still these alloys are relatively expensive and have several other serious shortcomings.

Off hand, it might seem rather peculiar that it should be at all difficult to find suitable materials for dairy equipment construction. Clean sweet milk would certainly appear rather innocuous to metals, but the fact is that it can be quite corrosive to a great number of materials. Furthermore, the quality of most dairy products is extremely sensitive to copper and iron contamination. Another peculiarity of the industry is also the very strict sanitary requirements. Every piece of equipment must be taken apart and scrubbed with strong cleaners every day. On top of that, relatively strong chemical sterilizers are regularly used before the equipment is again put to use.

The tremendous size and distribution of the industry, the great variety of products, the great seasonal variation in quantity of the products, the relatively very small margin of profit both to producers and distributors, the close supervision by Federal, state, and municipal authorities, all add to the complexity of equipment requirements and, consequently, to the difficulties in selecting the best and most economical materials for equipment construction.

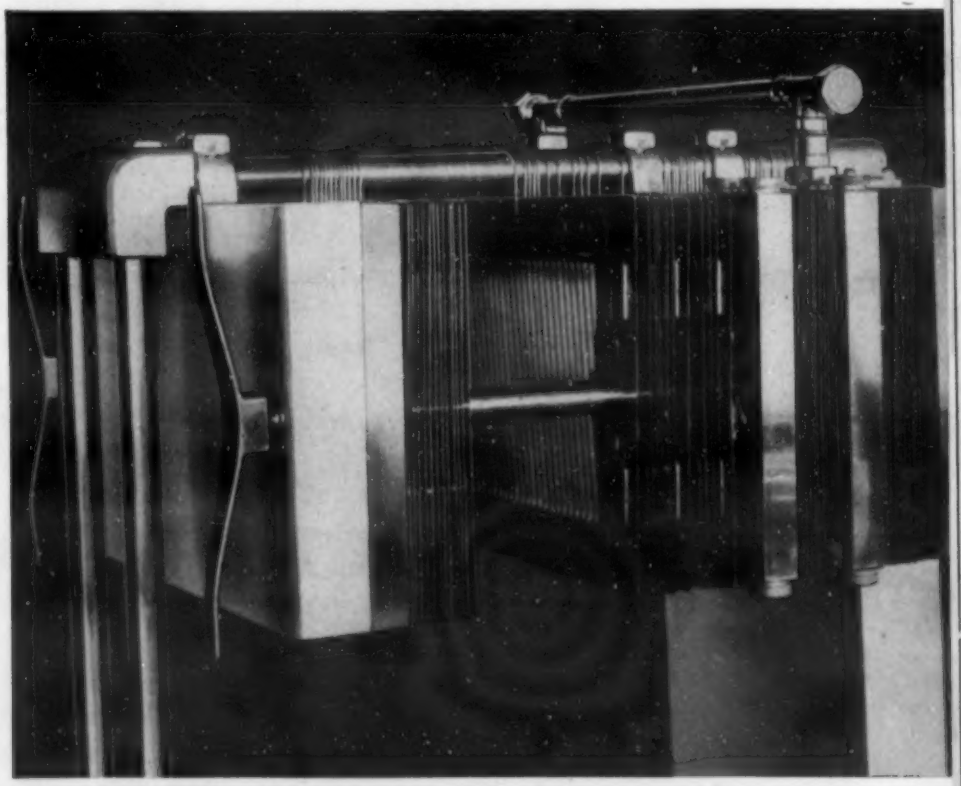
Magnitude of Milk Industry

The flow sheet, reproduced herewith, mostly based on Government statistics for 1938, gives a picture of the magnitude and complexity of the industry. As regards the number of various types of plants, there is much overlapping, since many plants have several types of activity in the same plant.

Aside from the tremendous total volume of milk produced each year, the most striking fact about the flow sheet is perhaps that it shows that over 40 per cent of the milk produced is still separated on the farm and the skimmilk fed to stock, while the cream goes to butter manufacture. Less than 30 per cent goes to the city pasteurizing, bottling, and ice cream plants for fluid milk, cream, ice cream, etc. The remaining 30 per cent is split into a great variety of manufactured products such as cheese; evaporated, condensed and dried milk, etc.

The trend in the industry has been definitely towards more and more factory production and better utilization of the by-products, but, as indicated in the flow sheet, there is still a tremendous volume of skimmilk for which no better use can be found than stock feeding on the farm. There is also a great deal of whey which is still being wasted, although every year more evaporators and dryers are being installed. This shift towards better utilization of by-products is very interesting from an equipment and metal point of view, both because of increased equipment requirement and because of the type of equipment required since a great deal of it does not come within the very strict regulation of the fluid milk industry.

It is also interesting because it opens up many possibilities for large volume operation with far



Left: A few 1,500-gal. jacketed milk pasteurizing units. The inside jackets, also the cover and agitator parts are constructed of Inconel; the outer jacket is of Monel metal. These units are welded throughout. (Courtesy: International Nickel Co.) Right: Full-flow plate equipment. The press is opened showing stainless steel plates. (Courtesy: Creamery Package Mfg. Co., Chicago)

better chemical engineering than has usually been employed in the dairy industry in the past. For instance, for evaporation of whey for animal feed, multiple effect evaporators of either steel or copper are the rule rather than the exception; while for the evaporation of whole milk or skimmilk, single effects of 18 and 8 or copper are still mostly used. Also, in whey powder production, highly efficient spray and drum dryers of various types are used, while for whole or skim the comparatively inefficient drying rolls are still very largely being used.

It is obvious that with such a variety of products, as indicated in the flow sheet, there will also be a tremendous variety of equipment, and it is, therefore, not possible here to discuss each piece of equipment. Instead of this, a short discussion will be given of the important materials of construction and typical pieces of equipment mentioned as examples.

Iron and Steel

In discussions of materials for dairy equipment, plain iron and steel are very frequently sadly neglected. Still, the quality of these materials, and especially the quality of the corrosion-preventing coatings employed for them, are of very great economic importance to the industry and definitely deserve more attention than they have been getting.

Bare iron and steel are of course being used for all kinds of auxiliary equipment for heat, power, and refrigeration. But curiously enough, the bare metal is also being used in increasing amounts for drying and evaporating equipment in direct contact with the products, especially in the by-products field, where a slight iron contamination is of little consequence, and may even be beneficial.

Galvanized or cadmium plated or metal dipped or sprayed iron and steel is used widely for conveyors and washing equipment (such as the can washer in one of illustrations) and also for supports and frames of various types, when this metal does not come in direct contact with the products. The same thing goes for painted or lacquered and enameled surfaces.

Glass lined or glass enameled steel has been used quite extensively for direct contact with dairy products in storage and transportation tanks, and also, to some extent, in processing equipment. It has lost somewhat in favor because of difficulty of repair if accidentally cracked or chipped, and also because the surface sometimes becomes rough after some years' use. It is very much to be hoped that this difficulty can be overcome, because a new glass surface has outstanding merit as far as concerns the preservation of the quality of the products. The actual smoothness of a glass or enameled surface is a highly desirable characteristic which is difficult to duplicate with even the most highly polished stainless steel.

Glass lined or enameled steel has, of course, a low heat transfer coefficient but this is not as important as might be expected, because the over-all heat transfer depends very largely on film formation. Since heat insulating films are usually thinner on smooth surfaces, glass lined equipment compares surprisingly well with stainless steel[2] or even copper equipment as regards heat transfer in many long time operations when the over-all rates of heat transfer are very low. In this connection, it must be pointed out that the effect of metals on heat transfer rates varies from one piece of apparatus to another. Where over-all heat transfer rates are low, the thermal conductivity of the metal is of little importance. However, where the over-all rates are high, as in high velocity heaters and coolers, the nature of the metal and its thickness are often important in determining rates of heat transfer.

The various new plastic coatings have been tried in the industry, and will probably find their place, particularly for outside surfaces. For this purpose they may have some advantage over uncoated metals, since water hardness spots or finger marks would not show up as badly as they do on highly polished metal. This would mean a considerable saving in cleaning labor. From a purely esthetic point of view it is also possible that people will tire of the bright stainless steel surfaces and will be quite relieved and find more beauty in either white or light colored plastic coatings.

Rubber-lined steel is being used to some extent for highly acid conditions such as in casein manufacture. It has also been found satisfactory for condensing pans for acid buttermilk; but in general plain copper pans are quite satisfactory for that purpose, and much cheaper to construct.

Low Alloy Steels

Various special steels with small amounts of alloying constituents, such as nickel, chrome and copper are being used in the construction of heating and cooling jackets and baffles, in order to prolong their lives. It is often found that not enough attention is paid to the unseen parts of dairy equipment, and that heating and cooling jackets will rust out long before the milk surfaces themselves are destroyed. Similarly, the special steels and cast irons which contain nickel, are being used to advantage for structural parts of bottle and can washing machines in which they provide resistance to corrosion by the alkaline solutions employed.

One very important use of steel in the dairy industry is for milk cans and milking pails. For this use the metal is heavily coated with tin by hot dipping. The old soldered types of cans and pails have nothing to recommend them except low price, and

it is rather surprising that the industry, with its high sanitary standards, had had so much patience with this equipment. Fortunately, good progress has been made in the last five years towards all drawn and welded construction of both pails and cans. There has also been some progress towards better tinning, but in that direction a great deal still remains to be done. A coated metal is, of course, fundamentally wrong for a piece of equipment which gets as much rough usage as a milk can, but price puts a definite limit to most possibilities of other materials.

There should, however, be excellent possibilities of simplifying the design and manufacture of the can, making a lighter and stronger can by increasing the strength of the metal, and improving the tin coating both as regards resistance to wear and non-porosity. The non-porosity of the coating is particularly important because, as the can leaves the can washers hot, there is bound to be some condensation on the inside surface after it cools down. This condensate will not attack tin but it is very corrosive to iron even when it is only exposed beneath microscopic pores in the tin coating. There seems to be no practical way of getting an absolutely dry can filled with absolutely dry air as it leaves the washer. All efforts must therefore be towards getting a non-porous tin coating or a non-porous coating of some other corrosion resistant and wear resistant material.

It has been claimed[3] that a non-porous tin coating can be produced by electrotinning on top of hot dipping, but this may increase the cost of the can too much. Another method has lately attracted considerable attention. This is the so-called Coronizing process, employing electroplated nickel with zinc or tin coatings, followed by a heat treatment of the sheet metal before it is manufactured into the finished article. It is also possible that considerable improvement can be made in the regular hot dipped coating by better plant control during the manufacturing process. Excellent porosity tests are available[4] but very few tin shops or their customers ever bother to use them.

Chromium plated steel is being used in some places, especially for handrails and trimmings. It is harder and better-looking than tin, and highly insoluble in dairy products. However, the same objection may be raised to chromium as to any other plating or coating—it is very difficult to produce a satisfactory coating, particularly on the inside of tubes and irregularly shaped containers, and on threaded parts which have to be taken apart and scrubbed with strong cleaners every day.

18 and 8 Chrome-Nickel Stainless Steel

The advantages of this alloy are well known, as already mentioned. It is probably as near to an ideal material for dairy equipment as we shall ever have. The main disadvantages are the relatively high cost and the sensitiveness to oxygen concentration cell corrosion or "crevice corrosion," that is, corrosion at places where two pieces of similar or dissimilar metal come very close together with a stagnant liquid film in between. This condition exists quite frequently in plate type heat transfer equipment, and also inside surface coolers which are made by welding two pieces of corrugated sheet metal together. No sure and generally practical remedy has as yet been found against this shortcoming of the alloy. The trouble in the plate equipment has, to some extent, been overcome with the newest type of plates, with contact points instead of lines. In addition, the plates are taken apart every day and thoroughly cleaned which in itself is a great help. The most difficult condition exists on the inside of the surface coolers, which cannot be opened for inspection and cleaning. In several cases these have pitted through, and our only hope is that some way will be found to protect the metal against this type of corrosion. In the meantime, we shall have to expect some failures of this type. However, this type of cooler construction is so cheap and efficient that it may not be advisable to abandon it at the present time, even if we shall have to expect some failures from time to time.

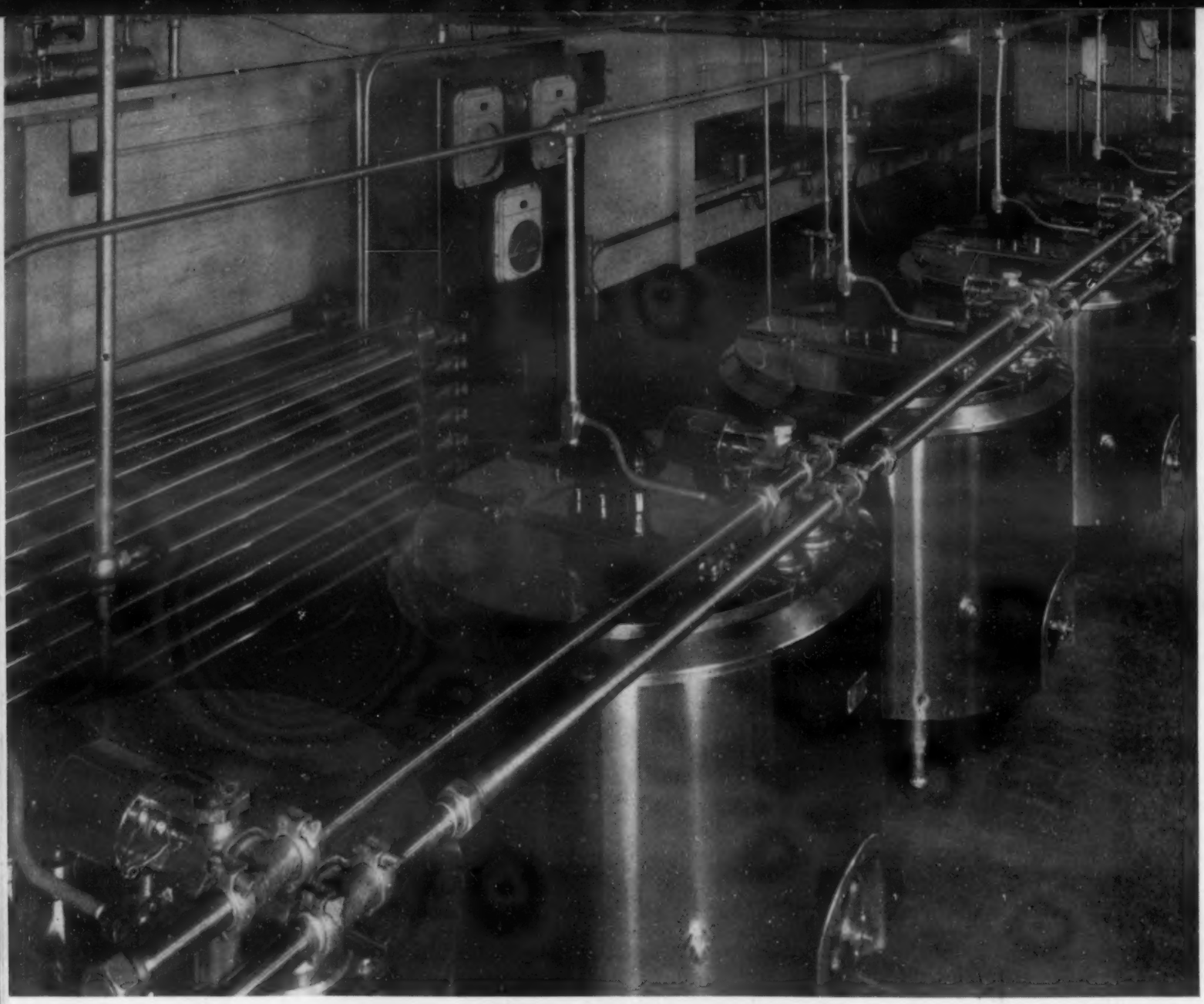
Another shortcoming of the 18 and 8 stainless alloy is that it is sensitive to brine corrosion. The danger can be considerably reduced by carefully keeping the pH of the brine above 7.6. In addition to this the presence of molybdenum in the 18 and 8 metal provides added protection against this type of corrosion. The addition of silver to the alloy has received considerable publicity but practical proof that it is of any benefit is yet lacking.

Some years ago, considerable trouble was experienced with weld decay, but this difficulty has very largely been overcome by the use of low carbon 18 and 8, and also by addition of columbium and titanium to the alloy. It is still assumed to be essential that very low carbon content be used for pieces of equipment with complicated welding such as surface coolers. For most simple tanks a higher carbon content will be just as satisfactory, if correct welding technique is used.

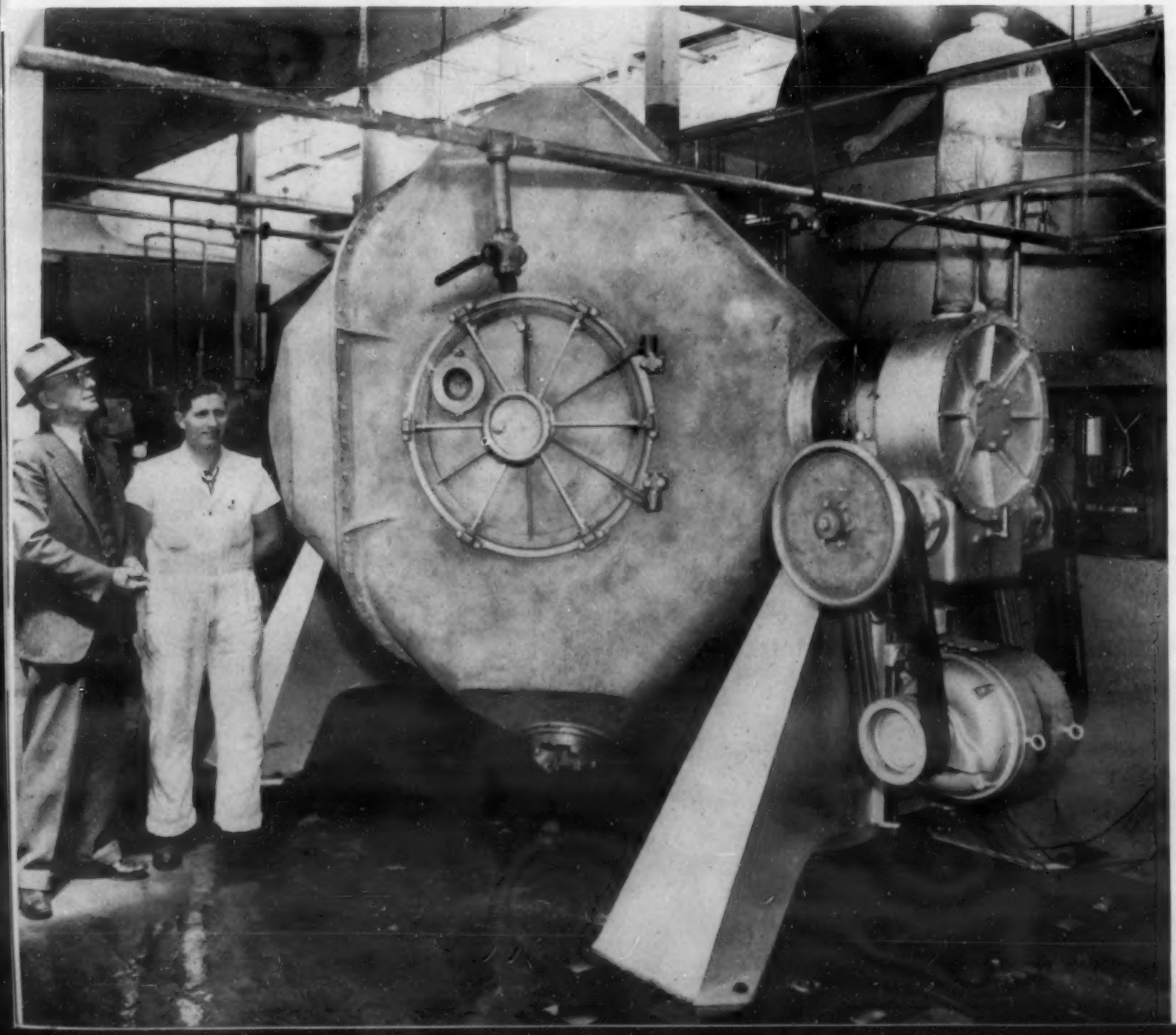
Some improvements are being made in the manufacture of seamless tubing, and it is to be hoped that this will bring lower prices. Progress has also been made in the making of so-called sanitary joints. All fittings are now being made without a recess either with or without the use of solder. It has been reported that the expanded solderless joint has not been successful in all places, but that the soldered recessless joint has been very successful.

Stainless Steel Castings

The greatest difficulty has been obtaining good



Precision tank holding system. The tanks, piping, control cabinet and heater (at left) are all stainless steel (18 and 8). (Courtesy Creamery Package Mfg. Co., Chicago).



A butter churn of sand cast aluminum alloy. It is capable of converting 660 gals. of cream into 2,580 lbs. of butter in about 1/2 hr. Its light weight reduces operating costs and the aluminum is said to protect the quality, flavor and color of the butter. (Courtesy: Jensen Machinery Co., Inc., Bloomfield, N. J.)

18 and 8 stainless casting for fittings, pumps, return bends, etc. Wherever volume will permit, the tendency now is toward using forgings which it is easier to get free from porosity. The cost of the finished articles is still very high on account of the great machining cost. There is a definite need for improvement in this direction and considerable work is being done in trying to find some addition to 18 and 8 stainless which will give a better casting alloy with better machining properties without sacrificing the non-corrosive properties.

It has been particularly difficult to get good 18 and 8 sanitary plug valves. Some progress is being made in that direction by the use of stainless alloys of different composition and hardness for the two parts of the valve.

In regard to the use of 18 and 8 stainless for insulated tanks, the greatest care should be exercised in putting on the insulation in such a way that it is kept free from moisture. It is particularly important that the steel surface be protected with an anti-corrosive paint before insulation is applied since a moisture layer close to the metal will encourage corrosion. In addition to this the insulating properties will, of course, be lost in a very short time if any moisture is permanently absorbed in the insulating material.

The relatively low coefficient of heat transmission of the iron alloys as compared to copper and copper alloys is of relatively small importance in most cases, because, as already mentioned with glass lined steel, when the total rate of heat transfer is low, the overall heat transfer depends so much on film formation. Also, the fact that these alloys are difficult to solder is of no great importance any more, since all welded construction has definitely become the goal of the industry. Of course, it is frequently not practical to weld tubes into the headers in heat exchange equipment or into sanitary fittings, because it would be prohibitively expensive to make repairs if it should ever be necessary. In these cases, excellent expanded or sweated joints are being used with the cracks or sharp corners filled with silver solder or pure tin.

Inconel and Chrome-Irons

This alloy looks very similar to 18 and 8 stainless and contains the same elements, but in different proportions. It contains about 14 per cent Cr, 80 per cent Ni, and only 6 per cent Fe. It is equal to 18 and 8 for all uses, and it is definitely superior to 18 and 8 for some particular uses such as cooling coils for buttermilk vats, etc. It also shows less corrosion in brine than 18 and 8. Up to now, the price of Inconel has been higher than 18 and 8, but the tendency has been towards adjustment to approximately the same level, at least for tubing.

There are a number of iron alloys on the market which contain chromium alone, or both chromium and nickel in proportions differing from that in the common 18 and 8 alloy. It is possible that some of these alloys could be used to advantage instead of 18 and 8 for certain types of equipment, and save us some money. However, at the present time, it may be better to standardize on 18 and 8 stainless and Inconel, which we know are satisfactory for most purposes.

Clad Metal

Clad metal with a thin layer of 18 and 8 or Inconel rolled together with steel sheet should be ideally suited for large insulated or jacketed storage tanks. It appears, however, that it is still quite difficult to produce satisfactory welds with this type of material, and that the extra cost of the welding when carefully made is almost as much as the saving in the cost of the materials. It therefore seems as if clad metals have no particular place in the dairy industry at the present time, except possibly for table tops and similar uses where no welding is involved.

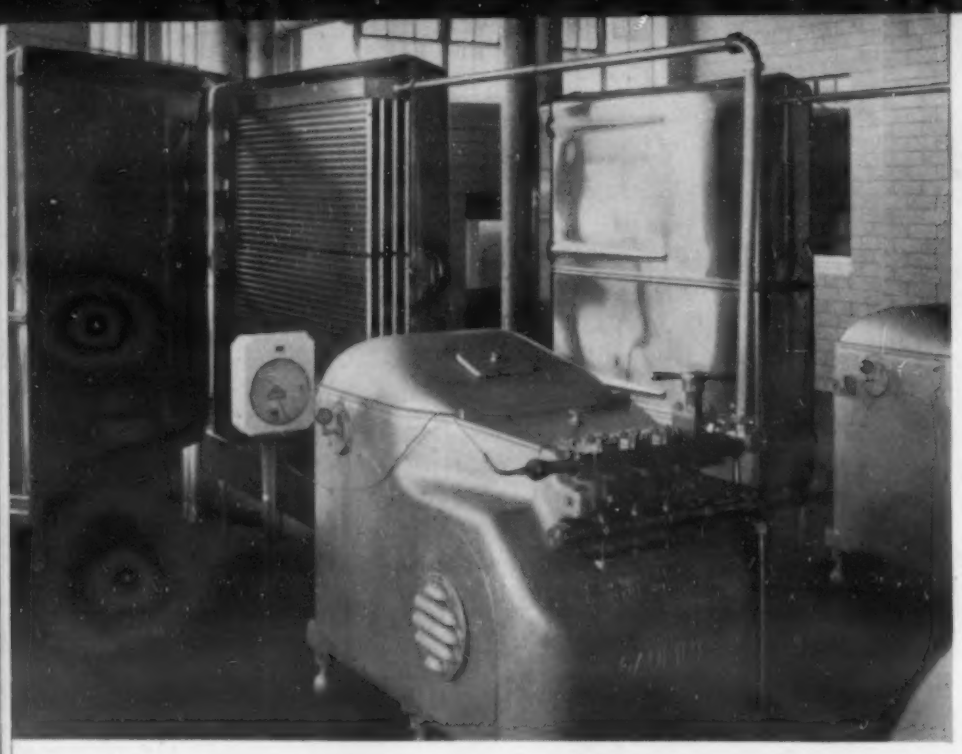
Copper

This, one of the oldest materials used in the industry, is in the later years being very largely replaced by stainless steel. Still, large amounts of copper equipment are in use, and there is still new equipment being constructed of this metal. This, in spite of the fact that copper is an oxidizing catalyst which tends to produce so-called oxidized flavors in dairy products. Of course, most of the copper is covered with tin, but bare copper has its specific uses, especially where low cost and very rapid heat transfer is desired, and where slight copper contamination is not objectionable, for instance for vats used in swiss cheese manufacture and for hot wells and vacuum pans for evaporation of acid by-products for animal feed.

For use in connection with brine as a cooling medium, copper is still preferable to stainless steel in spite of the fact that the straight weight loss corrosion rate is much higher than for stainless. However, copper corrodes evenly, and does not have the tendency to deep pitting shown in the stainless alloys.

The application of improved electroplating technique has also made it possible to get better tin coatings so that it is quite possible that tinned copper will not only keep its present position in the industry, but also see some expansion. It may also be possible to improve the hot tinning process for tubing and, if so, it might be advisable again to consider the use of copper tubing instead of stainless (which is four or five times as expensive) at least in country receiving stations and for raw milk lines in city plants.

Silver and chromium platings have been tried, but have not gained much headway probably because of



Two milk coolers, one with the covers closed and the other with one cover open, all of stainless steel. (Courtesy: Jensen Machinery Co., Inc., Bloomfield, N. J.)

A pasteurizing holder of stainless steel (18 and 8) with a capacity of 12,000 lbs. per hr. (Courtesy: E. A. Kaestner Co., Baltimore, Md.)

the difficulty of getting non-porous and non-peeling coatings. Chromium is well suited for contact with dairy products, and is much harder than a tin coating. However, any type of electrolytic plating must be made on the finished equipment, because the coating would be destroyed by soldering or welding, and this frequently means great difficulty in getting a sufficiently heavy and non-porous coating on articles which have complicated forms.

Copper-Nickel Alloys

These alloys have been used widely through the industry under such names as nickel-silver, Navy metal, Waukesha metal, Diamond metal, NoMar metal, White metal, Ambrac, etc. The common practice of referring to them as "nickel alloy" has been unfortunate, since this term implies that they consist principally of nickel, whereas they actually contain from 60 to 70 per cent Cu.

Because of their high copper content, they share some of the disadvantages of copper, particularly with respect to effects on the flavor and keeping qualities of dairy products. Consequently, there is a growing tendency to restrict their use to those services where the conditions of exposure are favorable and where the desirable properties of the alloys outweigh their possible disadvantages from the standpoint of flavor effects. In this connection, recent studies[3] have shown that certain compositions are better than others and the investigators concluded that the use of such compositions for pipe line fittings need not be expected to lead to flavor troubles. The preferred compositions contain substantial amounts of tin, lead, and zinc, and a smaller amount of iron. The beneficial effect of these other elements was also demonstrated by the unpublished results of tests in our laboratories on some 26 copper-nickel alloy compositions.

The principal advantages of these alloy fittings include their relatively low cost as compared with stainless steel, and the ease with which they can be cast and machined. They are also superior to stainless steel for parts which must run in rubbing contact without seizing, such as in pumps and plug valves.

The use of copper-nickel alloys in wrought forms, such as sanitary tubing, which can be obtained readily in stainless steel or Inconel should be discouraged. However, until stainless steel fittings are more readily available at considerably lower cost, it seems likely that copper-nickel alloys will continue to find extensive use for uncoated cast fittings and pump parts, especially for cold products. The usual excuse for the use of copper-nickel alloy fittings is that such a small area of metal surface comes in contact with the products in the fittings when all the rest of the equipment is made of 18 and 8 stainless. This is somewhat misleading, because the amount of metal which goes in solution depends both on the anodic and cathodic area so that the fact that the anodic area is very small does not necessarily mean that a small amount of copper will go in solution. As a matter of fact, there have been cases where a single copper thermometer stem in a stainless steel vat has caused trouble.

Monel metal which has a high nickel content is still quite widely used in ice cream hoppers, ice cream freezer cylinders, and for tops of ice cream

cabinets, etc., and has, as far as is known, not given rise to any complaints, probably because the temperatures are so low that only insignificant amounts of metal are dissolved. This alloy can certainly not be recommended for general use in contact with dairy products, but it is, of course, quite satisfactory for outside trims.

Nickel

About 10 years ago, a great deal of dairy equipment was made of this metal. It has many advantages over tinned copper, but it was soon found that it was entirely unsuited for contact with milk which is cooling down from a high temperature. On the other hand, it is quite satisfactory for cold milk, or for milk which is heating up. This peculiarity is explained by the fact that when milk is being heated up there is a tendency to form almost invisible protective films on the metal, but when the milk is cooling down, no such film formation takes place.[6] The better thermal conductivity of nickel as compared with stainless steel or Inconel, has led to the choice of nickel in preference to these other materials for tubes in milk heating units in some cases when very high transfer rates are desired. It is reported that some of the evaporator manufacturers who have been using stainless steel tubes in their evaporators are now showing a renewed interest in nickel, since practical tests have shown that for the same area of heating surface evaporators with nickel tubes have a higher capacity than similar evaporators with stainless steel tubes.

Nickel is also being used to a considerable extent for various special uses, such as freezer tubes in continuous ice cream freezers.

Aluminum

This metal has many excellent properties for use with food products, but it has lost somewhat in favor during the last years because of its sensitiveness to electrolytic corrosion in contact with other metals in a liquid medium. It is being used for covers, etc., and definitely has its place where low cost and light weight is desirable even if it does not look as good as the stainless alloys. Good, remarkably hard aluminum milk cans are now available, and it is felt that this may be one use where it should be tried on a large scale, unless we can get a light and reasonably priced stainless can in the near future. Aluminum is being used for transportation and storage tanks for cold products, but apparently there is not enough price differential on the finished equipment as compared to 18 and 8 stainless steel to make it attractive enough to the industry to overlook its disadvantages. The aluminum surface is definitely softer and consequently somewhat more difficult to clean than an 18 and 8 or Inconel surface. The tendency of aluminum to dissolve in alkaline cleaners can very easily be overcome by the addition of silicates to the cleaners, and there are plenty of good aluminum cleaners on the market.

Complete pasteurizing units made of aluminum have been in service for many years, and have in general given very satisfactory service in places where the equipment receives proper treatment.

Conclusions

In spite of serious shortcomings of the alloys, the discovery of 18 and 8 stainless and of Inconel have made two excellent materials available for dairy equipment construction. Other metals, such as steel, copper, various copper alloys, aluminum, nickel and nickel alloys all have their place and are still being widely used, although the stainless alloys definitely predominate in new equipment for surfaces which come in direct contact with the products.

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The Pressing of Metal Powders

BY RICHARD P. SEELIG

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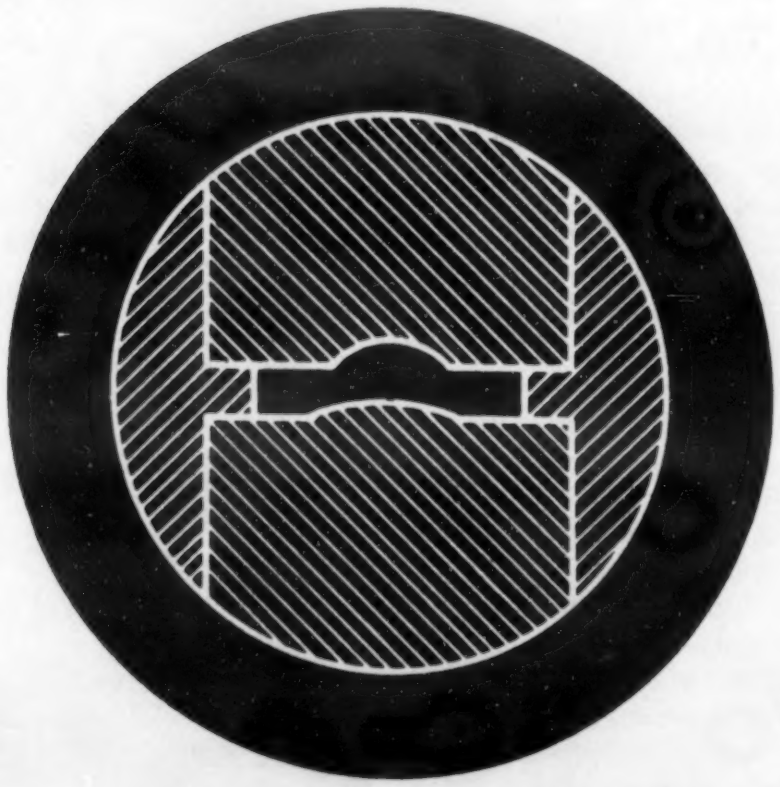

Fig. 1—Metal powder pressing die comprising four sections.

This is that rarest of all things—an article on powder metallurgy practice that really tells the engineer who has to design the die and supervise the pressing operation, how these things should be done. Not only how he may expect the powder particles to behave as individuals or en masse, but what he should do about die-filling, ejection of the pressed compact, press capacity, lubrication, die-setting, etc., are covered. And the reader will find lots of interesting parallels and contrasts between powder pressing and other metal-forming operations.—The Editors.

METHODS OF COMPRESSION of metal powders have progressed greatly during the last few years so that today many complicated shapes can be pressed that formerly were considered impossible. Just as the complexity of dies for die casting processes has created a new technique in die design, so the future of powder metallurgy must rest largely upon a study of the fundamentals covering the compression of metal powders.

The compressibility of most metals decreases with increasing pressure. Plastic deformation of solid metals does not follow simple mechanical laws, because such processes as work hardening and other changes of structure occur. Generally, all resistance to deformation by external forces decreases with increase in temperature.

Compression of Metal Powders

Phenomena observed in the compression test with solid metals seem to play a part in the compression of metal powders. Each powder particle may be considered an individual compression test specimen but of irregular shape. In this connection it may be interesting to note a phenomenon that occurs in the compression of cast iron: Notches in the specimen increase not only the strength but also the deformability under pressure[1]. This may have a bearing on

the problem of particle shape, especially in brittle powdered metals.

When considering the whole mass of powder particles, we do not deal with the solid metal in the ordinary sense of the word. Perhaps phenomena displayed in compressing powders can be said to occur in an intermediate state between the liquid and the solid, due to flowing and other compression characteristics. The metal is, of course, confined in a die on all sides. The stress distribution is therefore different from what occurs in the standard compression test.

Since the pressure acts on all sides the powder in the die resembles somewhat a liquid in a vessel under pressure. "Pressure cones," which are noted in the standard compression test, do not develop in this case. On the other hand, one of the most important phenomena in metal powder compression is that the pressure is not evenly distributed. Part of it is absorbed by internal friction in the metal powder, part by friction of the powder with the die walls. At this point the comparison with the liquid state no longer holds true, and proper die design must take this into consideration.

Crystal Behavior in Pressing

The behavior of metal powder under pressure is found to be complicated by the fact that a great number of small particles, which lack any metallic bond except that produced by the pressure, are closely packed. This is considered a mechanical interlocking, together with adhesive forces and possibly some kind of cold welding. Under pressure the particles are in the state of cold deformation.

There is no evidence to show that there is a preferred crystal orientation in compressed powders. Just as in the case of solid metals, no theory can succeed in predicting the movements of individual particles (grains) without taking into account a vast number of variables: Every particle "flows" in a manner dictated by its interaction with neighboring material.

During the latter stage of the metal powder compression, the material approaches more and more the state of a polycrystalline mass held together by the action of pressure, friction and adhesion. Little or no flowing takes place. Another point to be considered is the stress condition. Although we speak of pressing operation, the individual particles are not necessarily under compressive stress. As a matter of fact, all kinds of stresses probably occur.

These considerations point to the conclusion that no preferred orientation may be found in compressed metal powder compacts. This has been substantiated by Trzebiatowski's experiments with copper and gold powders[2].

In powder metallurgy practice it is important in many cases to avoid porosity, and moreover, to have as close a contact between the particles as possible. This not only facilitates the subsequent sintering operation, but also increases the strength of a compact in the as-pressed state. Thus, softer and more plastic metals will show greater strength than brittle ones in the form of pressed (unsintered) parts after using the same pressure, (copper vs. tungsten).

General Requirements

As already pointed out, cold deformation plays an important part. Compression is rendered more difficult if the powder is in the cold-worked state. This is why powders of the same metal, but manufactured in a different way, can be fundamentally different as far as their pressing properties are concerned. It makes no difference whether this hardened condition is caused by mechanical working, electrolysis, etc. It may be relieved by annealing the powder.

We have also seen that, besides the simple deformation, friction between particles occurs. This, together with surface films by oxidation, may be one of the more important factors as far as the subsequent sintering operation is concerned.

The properties of unsintered powder compacts have not been thoroughly investigated due to the fact that such parts are used only to a very limited extent. It is usually simply a requirement that compacts be "strong enough to handle" which means that the part should not be damaged (sharp edges and corners) on the way from the press to the furnace. There are instances, however, where other requirements are necessary. For instance, certain addition agents (master alloys) can successfully be produced by powder pressing technique. A special technique has been developed for the purpose. The result is the production of a part which must withstand packing and transportation. It has to dissolve readily in a molten bath and disperse through the bath at the highest possible rate.

A report by Skaupy and Kantorowicz[3] on the electrical conductivity of pressed powders indicates that not only the amount of pressure but the rate of application of the load are factors to be considered. In some cases, the conductivity increases suddenly at a critical pressure. This was found to be true especially with powders that have undergone little or no work-hardening. In most cases the finer the powder, the higher the resistance. A most interesting point is that it was found that thin oxide layers seem to have no appreciable influence.

Only very few data on physical properties of such unsintered powder compacts exist, to the author's knowledge.

When loosely filled into a die cavity, the powder occupies a great deal more room than after it has been compressed; its apparent density is only a frac-

tion, between ⅓ and 1/6 of that of the solid metal. The remaining space is taken by voids which are enclosed between the different particles. Powder particles are not necessarily of spherical shape. As a rule they are not spherical, and experience seems to indicate that irregular shaped particles are to be preferred, where high density and strength are desired in the compressed compact.

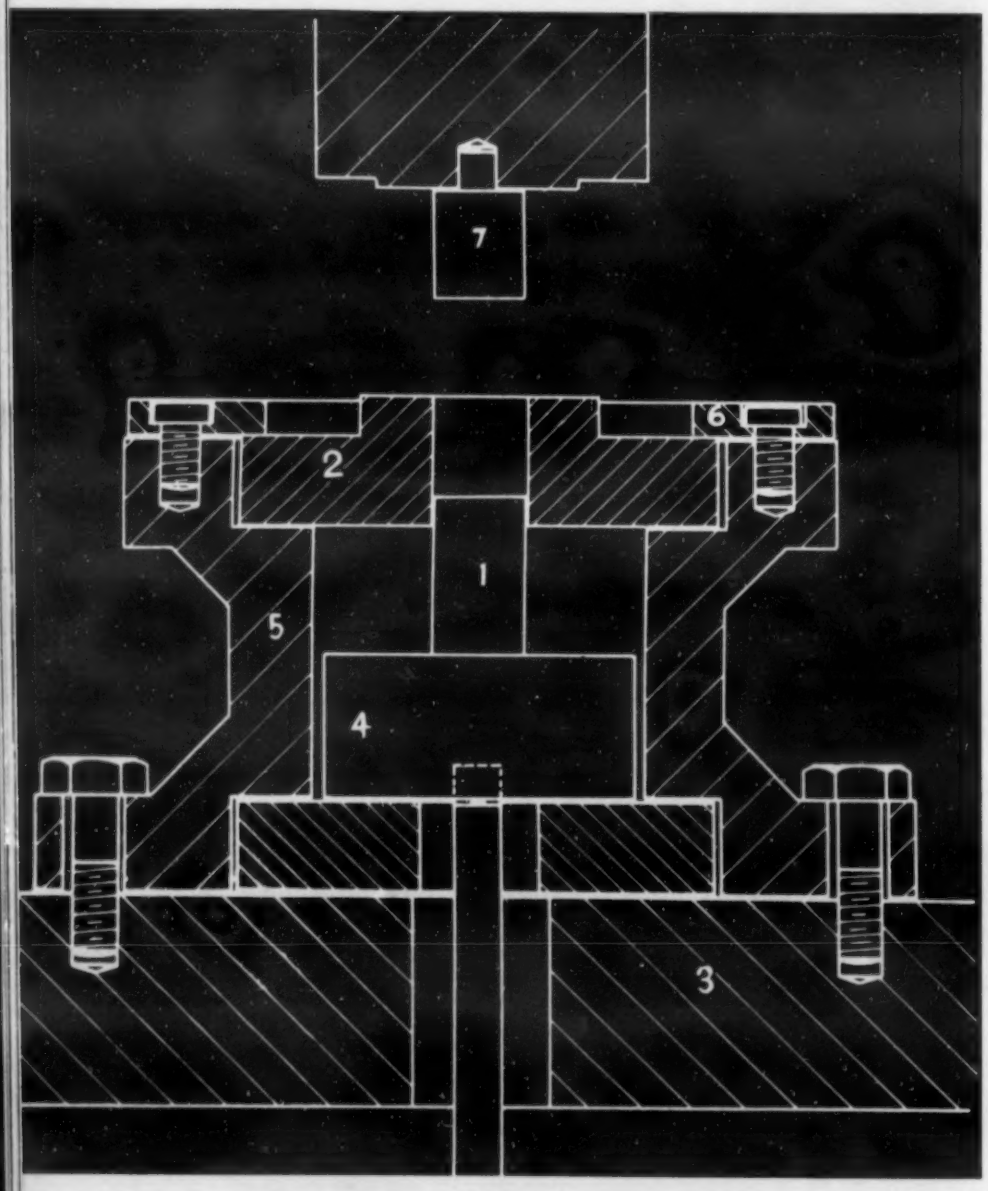

Fig. 2.—The technique of setting a powder metallurgy die into the press.

Die Design Problems

The main problem of the pressing operation lies in the fact that it is necessary to fill the die, on the average, with about three times as much material by volume as the desired shape. It is this very factor which is responsible for some limitations of the powder metallurgy process.

Thus, the fact which was stressed above, namely, that metal powders do not act either like liquids or plastic materials, gains its practical importance. When filling a die with powder one must visualize that this powder will not flow around corners or fill out intricate shapes. A number of devices have been found, however, to eliminate part of this difficulty.

For production work, the compressed piece must be removed from the die automatically. The best die design requires that the largest cross-section of the die is on the side toward which the piece is being ejected. In some cases split dies will facilitate the removal. The straight-line pushing of a compact out of the die requires considerable pressure and usually a long stroke, depending upon size and shape of the part. The compact exerts a pressure against the side walls of the die which causes friction and leads in many cases to failure.

The stroke should be long to allow for ejection through the additional die space which has been provided for the 3 to 1 compression. Laminations are the result of the stressed condition of the compact in the die. As soon as one section of this compact leaves the die it has a tendency to expand, while the remaining part is still held in the die, with the result that as ejection proceeds a series of cracks is formed.

It should be borne in mind that all metal powders do not act alike.

The problems arising during the compression of powders have been described so as to understand better the necessity for specialized equipment and tools. It is the engineer's task to overcome these obstacles and to make this manufacturing process as widely applicable as possible.

Press and Die Equipment

Practically any press may be used for compression of metal powders. It is well to bear in mind, however, that a considerable filling space is required for relatively long parts. For such an article, a press with a good sized ram stroke should be selected. The same holds true for the ejector. An important point is that high pressures are in most cases required where high density and strength are important; therefore, when large cross-sections are involved, a high capacity press must be selected. In many cases the capacity of the available press equipment constitutes a limitation of the parts that may be handled.

From the economical point of view it is, of course, desirable to use a high-speed press so as to turn out the maximum amount of parts per time unit.

Some people argue that a hydraulic press has a different effect from a mechanical press of the same capacity. This is due to a difference in the manner in which the load is applied—an effect that becomes apparent in laminations on the compact and has to do, it is said, with the air trapped between the powder particles.

Cavities in the dies have additional space for filling-in the required amount of powder. The material

and wall thickness have to be such as to withstand the high pressures, which range in commercial practice from 20 to 100 tons per sq. in. For simple shapes, two punches are made which fit into the die with little clearance. One is for compression, the other for ejection. The clearance should be sufficiently small to prevent the powder from blowing out during the pressing stroke, but it has to allow, on the other hand, for the escape of the air. When simple and symmetrical shapes are compressed such as bars, bushings, etc., the top and bottom punch have the same profile. In some cases, however, where the piece has not the same cross-section throughout (flanges, etc.), the bottom punch represents the shape of one end, and the top punch of the other.

The die walls are smooth so as to facilitate ejection. For the same purpose a taper is provided if the tolerances allow. The amount of taper is based on experience with each particular product. This avoids excessive friction, sticking of particles to the walls, roughening of the surface, and lamination.

Lubrication

In order to counteract the same difficulties, a lubricant is often applied to the die. This cannot be an oily substance because it would penetrate the porous metal compact and would leave carbonaceous residues upon heat treatment. Soapy lubricants have proven most successful when they are suspended in a solvent which volatilizes even before the powder is filled into the die. Various means for automatic and constant supply of the lubricant may be provided.

Naturally great care is taken to produce smooth and accurate surfaces throughout the die. Since it is often impossible to grind all surfaces inside the die, it may be composed of several parts. These sections are shrunk together by a tool steel ring which is not hardened. This ring acts at the same time as a safety device and may also be applied to one-piece dies (Fig. 1).

There are intricate parts that can be manufactured from metal powders by applying several pressing operations in a single die. Automatic operation of such dies may require special and intricate machinery. They also may be hand-operated which means that the ejection of the finished compacts is not done automatically after the compression is completed. Manual operation is often used if an insert has to be removed from the die or the die itself has to be taken apart in order to remove the compact. This is relatively a time consuming operation. It may be justified, however, because in this way parts can be manufactured whose production, by orthodox casting, forging and machining methods, may be

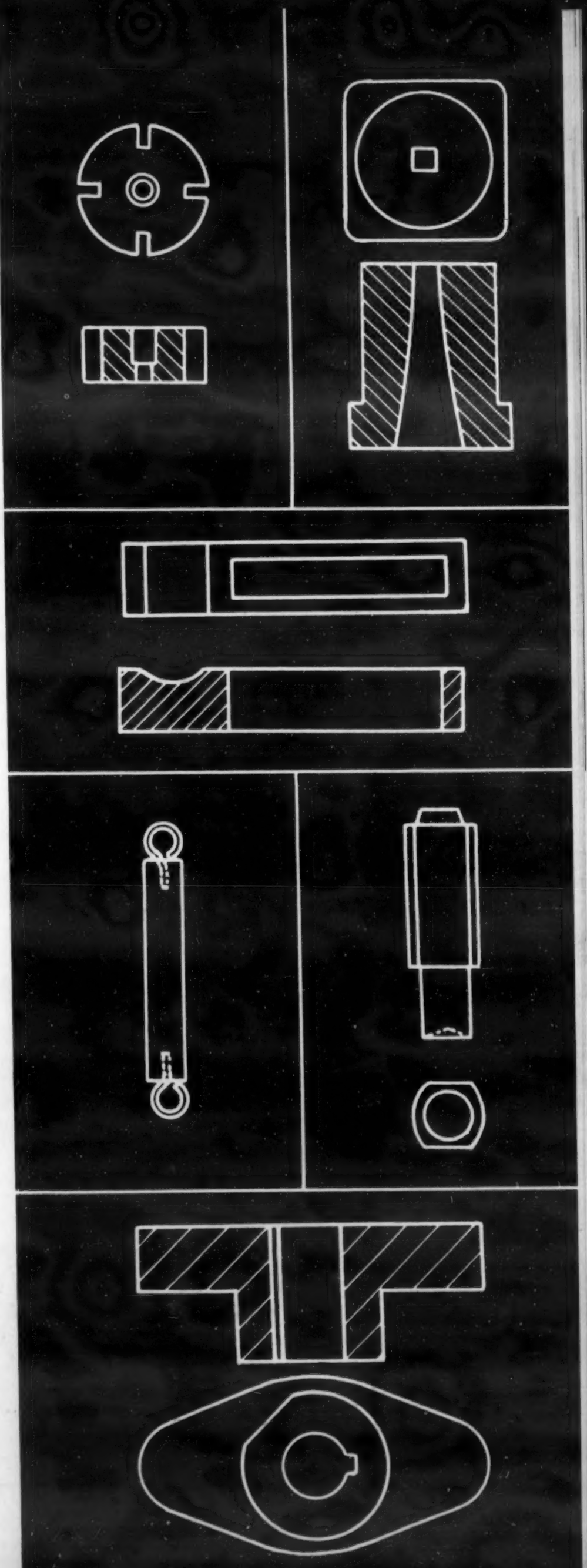

Fig. 3.—Some parts made by powder metallurgy.

very complicated and involve a great number of operations and a great deal of handling.

The Pressing Operation

The technique of setting a powder metallurgy die into the press is not a great deal different from ordinary die setting. In the simplest case the bottom punch 1 (Fig. 2), which takes care of the ejection, is connected to a lower ram in the press by means of a rod 2, which may be, for instance, 1 in. in diameter. It is the length of this part that must be selected according to the height of the die to be used. In this way it is possible to raise the bottom punch (knock out) flush with the top face of the die so that the compact may be removed conveniently. It is usually not permissible to press onto this ejector rod. Therefore, other means have to be provided to transmit the pressing load to the bolster place or table of the press 3. The bottom punch itself is connected tightly to this pressure-transmitting part 4 and extends somewhat into the die which, in turn, is held suspended in a so-called die adapter 5. By setting the die into the adapter so that it fits over the bottom punch, its location is completely defined and it can be clamped down in this position 6. The top punch 7 is held in a punch adapter connected with the slide of the press. It has to be set accurately and rigidly to fit into the die so as not to permit movement in any direction under the high pressure it exerts on the powder.

After the die is set, the pressure or the stroke of the ram (depending upon what type of press is being used for the job), the stroke of the ejector, and the speed have to be adjusted on the press.

The operation begins with the feeding of powder into the die, which may be done by hand or automatically. In a good many cases sufficiently speedy operation is obtained by filling the powder on a tray around the die and pushing it into the die before each stroke. For high production purposes a funnel arrangement with an automatic leveling mechanism is used. The height of the bottom punch is arranged so that the amount of powder required fills the die flush with the top. During the pressing operation the punch moves into the die. The press is released either when the desired pressure is reached or when the ram has traveled a pre-determined distance; then the ejector throws the compact out of the die, after which it is taken away and stacked until there is a sufficient quantity to charge the sintering furnace.

Speed of Pressing

An important factor is the speed of the pressing operation. The question is often raised as to how many parts per minute can be pressed in a certain press. An accurate prediction cannot always be made as metal powders react differently under compression. Some need plenty of lubrication, others need none. Some have to be leveled off carefully in the die, others fill up easily by themselves, and still others may adhere to the punches and die parts. The size and shape of the part to be pressed may also cause variations in the number of parts per unit time that can be compressed.

The slug or compact resulting from the pressing operation may have considerable strength and hardness especially if it is composed of one of the ductile metals. Severe stress or, more particularly, shock will break such a piece. Porosity is, of course, a function of the pressure as well as particle size distribution.

The production of parts by the powder metallurgy process has proved to be a unique method by which it is possible to produce certain material characteristics that cannot be achieved in any other way. Moreover, it is a process that yields parts of prescribed size and shape, which, in turn, saves machining costs. In all cases where strength is a factor, a subsequent heat treating operation is applied. Thus, the most universal practice in powder metallurgy consists of cold pressing and subsequent sintering. Sometimes a second pressing operation (coining) is used after the sintering.

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A REVIEW • PART 4 • CONCLUDED FROM NOVEMBER

Bearing Metals from the Point of View of Strategic Materials

by H. W. GILLETT, H. W. RUSSELL and R. W. DAYTON
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THE FEASIBILITY OF REPLACEMENT of bearing metals containing tin by those free from or low in tin, depends on the type of service.

At one extreme come the uses for leadless bronzes of the phosphor bronze type or of the 88 Cu, 8 Sn, 4 Zn type, under pressures where softer materials flow or pound out. Since there is no conformability, the shaft and bearing must be machined and surfaced with a high degree of precision, the shaft and bearing must be very stiff to avoid deflection, and ample lubrication must be assured. To prevent seizure during starting and stopping, the shaft must be very hard. In such bearings, if lubrication does fail, damage is likely to be great. Other materials of similar compressive strength might be used.

Zinc-base Alloys

A hard alloy that has had limited use in service as bushings where bronze bushings are the rule, is "Lumen bronze," 86 Zn, 10 Cu, 4 Al plus a trace of Mg. This is very hard, around 120 Brinell, and very brittle. Other allied compositions are "Sampson Metal",[88] 88 Zn, 4 Cu, 8 Al and an alloy of 88 Zn, 10 Cu, 2 Al[89] said to be good for high speed and light loads.

The tendency abroad has been to decrease the copper content and depend upon aluminum for hardening the zinc. A circular of the Bureau of Standards[90] cites over 70 zinc-base alloys suggested by foreign workers, most of which are essentually Zn-Al-Cu alloys, though some are Zn-Sn with Sb or Cu, and Pb. Schmid and Weber[91] advocate Zn with only ½ to 1 per cent Cu and with 4 to 10 per cent Al, of 80 to 105 Brinell, as substitutes for red brass or bronze. Voight[92] also considers them substitutes for bearing bronzes.

The substitution appears to have been attempted chiefly in heavily loaded bearings where the high compressive strength of the zinc-base alloys might be utilized. Kühnel[93] gives the Brinell hardness of zinc-base alloys with 2 to 5 per cent Cu and 2.5 to 5 per cent Al as 75 to 120 at room temperature and 50 to 95 at 212 deg. F., clearly in the range of the bearing bronzes and far removed from the babbitts. These alloys were suggested for bushings a long time ago; if they were really of wide applicability, their cheapness should have brought them into wider use than they have actually attained.

It seems odd that comment is lacking on the corrodibility of such bearings, which, from the analogy with cadmium-base bearings, would obviously have been met had they been used at elevated temperature in corrosive oil. One cannot with full assurance appraise them as potentially satisfactory substitutes for bronzes, though they may turn out to have been sadly neglected. As the Bureau of Standards[90] pointed out, zinc and zinc-rich solid solutions seem very prone to seizure, which limits their use where there is any likelihood of starved lubrication.

The Aluminum-Bronze Group

More commonly the replacements in slow speed,

high load service would be a regular aluminum bronze, made so as to be free from abrasive Al_2O_3 particles, or those lower in aluminum, such as 86.5 Cu, 8 Zn, 4 Al, 1.50 Fe, or 94.5 Cu, 5 Al, 0.50 Ni, or a regular bronze in which part of the tin is replaced by nickel, e.g. one of 90 Cu, 5 Sn, 5 Ni which is considered by Dunlap[94] to have useful bearing properties. Stang and Sweetman[95] comment on the propensity of aluminum bronze to score the mating steel part. The silicon bronzes might serve, but their behavior in bearings seems not to have been very much explored.

In some uses, sheer strength, combined with some approach to antiscoring properties is needed, as in the bearing sleeve for adjustable propellers for aircraft, for which a 2.5 per cent Be beryllium bronze, heat treated to around 400 Brinell, has been used.[96] There is, however, relatively little use in ordinary bearings for very hard bronzes. Gears are another matter, outside the scope of the present discussion.

Compatibility with Lead

In bearings it is generally preferred to use some lead, whether the reason be that a smear of lead is produced on the face of the bearing to give "E.P." properties, or that the lead pools are useful as pockets for the embedment of grit. Hence 80 Cu, 10 Sn, 10 Pb is very largely used. The tinless bronzes containing aluminum or silicon are not ordinarily considered to be compatible with lead, but it is claimed[97] that it may be found possible to introduce up to 10 per cent Pb into aluminum bronzes, though such alloys are "as yet only in an early stage of development." A tin-less, or very low tin, alloy that is compatible with lead and which would be substitutable for 80-10-10 would be an asset.

Holding the Tin Content Down

The low tin alloys such as 80 Cu, 5 Sn, 5 Zn, 10 Pb or an ordinary "red brass," 85-5-5-5, would serve many of the uses in which 80-10-10 is now used, and, as has been discussed in Part II, (October, 1940) the tin in such alloys can come almost entirely from scrap. Hence the 88 Cu, 4 Sn, 4 Zn, 4 Pb bronze used in small ends of automobile connecting rods, to resist the heavy loads, is not a serious problem.

Where bushings are used primarily for convenience in assembly, as they are in many lightly loaded services, a brass tube lined with a lead base babbitt would serve as well.

The bronze bushing problem is serious in respect to tin requirements only because the bushings are massive and not mere linings, so that even though the tin percentage is not high, the total tin requirement mounts up. However, the requirement for bronze bearings is probably not as great as for bronze castings for other uses. Many tin-less bronzes will serve nicely for corrosion-resistant castings and such a substitution is more feasible than to attempt complete replacement of all tin in bearing bronzes.

Babbitt Replacement

At the other end of the scale in bearing requirements are those uses to which the softer grades of tin-base babbitt are now applied. The appreciation that the strength of babbitt is enhanced as the thickness of the lining is decreased has already led to great reduction in the volume of babbitt required in automotive bearings, which are required in such great numbers. This trend and a coincident trend toward holding automotive engine temperatures down, for reasons not wholly related to bearings, result in passenger car engine design in which a standard lead base babbitt can be directly substituted.

Underwood[98] points out that more good has been done by decreasing babbitt thickness than by juggling percentages of tin, antimony and copper or by adding other elements, also that when babbitt linings were $\frac{1}{8}$ in. thick, lead-base babbitt was not as satisfactory as tin-base, but in the present day thin linings, lead-base can be used to replace it, if proper design is used. That this is a fact is shown by the use in Buicks in the 1937 to 1940 models of S.A.E. 14 lead-base babbitt, 75 Pb, 15 Sb, 10 Sn, on steel backs.

1940 Pontiacs are also reported to use lead-base babbitt on steel backs. Such substitutions bring up questions of the proper backing to use, which we shall refer to later.

With lead-base babbitt, containing only 1/9 to $\frac{1}{8}$ the amount of tin required in the tin-base babbitts, demonstrated by large scale use as serviceable for passenger car automotive engine bearings, it is obvious that the tin requirements for this tonnage use can be drastically decreased without any difficulty. Similarly, the soft tin-base babbitt could very often be replaced by one of the harder lead-base babbitts, in moderately thick linings. The objection to such replacement is more often that the plant doesn't want to have lead-base babbitt around for fear of an accidental contamination of the tin-base babbitt. But the far greater tonnage of lead-base than of tin-base sold for general babbitting indicates that the lead-base alloys are quite generally usable. However, there remain important uses where tin-base seems to be required rather than ordinary lead-base.

So we may turn our attention to the group of requirements intermediate between those served by hard bronzes and soft babbitts, first where the strongest or "high-grade" tin-base babbitt is required, as where the operating temperature is such that the ordinary lead-base babbitt is too soft in massive form and where the design calls for a thick babbitt lining rather than a thin one, and, second, where

even tin-base babbitt will not satisfactorily serve. The second case does not strictly come under our topic of substitution for tin, but in a way it does, since the lack of a better material may force the design to be altered from that which the designer would prefer, in order that the tin-base babbitt may get by, or it may force a shift to a leaded bronze bearing which does require tin.

One should also consider, in the cases where the thin lead-base babbitt containing 10 per cent Sn is applicable, whether that babbitt cannot be substituted by one containing still less tin, or none at all.

Cases where even high grade tin-base babbitt is not considered quite satisfactory are in the Ford floating bushing, in truck and bus engines, in some Diesel engines and in high-output airplane engines.

Bearing makers have put forth a variety of alloys for lining bearings for these services, including modifications of the lead-base babbitt, alkali-hardened lead, cadmium-base babbitts, copper-lead, copper-low tin with high lead, and silver.

In this group the ability to bond to the backing and the ability to resist corrosion by oxidized or acid oil have to be examined carefully in appraising their ability to replace tin-base babbitts, since the tin-base alloys are in general thoroughly satisfactory in both respects. The desire is to carry operating temperatures to higher levels than with tin base, and elevated temperatures bring out deficiencies in corrosion resistance that would scarcely be noted at lower ones.

Efforts to improve the lead-base babbitts, especially for use as railway bearing liners, reported from Germany by Zunker[99] and von Schwarz[100] have taken the direction of trying to get hardness with less tin than in the previous lead-base alloys.

While American lead-base alloys usually contain 75 to 80 Pb, 15 Sb and 5-10 Sn with not over ½ per cent Cu, the chief German alloy of this type appears to be that of "Einheitsmetall," 80 Pb, 14 Sb, 5 Sn, 1 Cu. Another German composition is 75 Pb, 15 Sb, 8 Sn, 2 Cu. Zunker cut the lead to 71 or 72, raised the antimony to 20, cut the tin to 2 or 3, raised the copper to 2 or 3 and introduced about 1 per cent each of Mn, Fe, Cd, Zn and As, without, in the room temperature tests he made, finding anything that appeared superior to Einheitsmetall.

von Schwarz advocates very high arsenic in a series of Pb-Sb-As alloys with the trade name "Palid," the composition he seems to prefer being 86 Pb, 8 Sb, 6 As. As has been shown in Part III, (November, 1940) the hardness of this alloy over most of the 200 to 300 deg. F. range approximates that of tin-base babbitt, but it is softer at 300 deg. F. It has been stated[101] that arsenic injures the bonding properties of lead-base babbitts and embrittles them. In American specifications for lead-base babbitts, arsenic is usually held below 0.20 per cent. The laboratory test cited by von Schwarz is insufficient to prove much about the practical utility of the alloy.

The Alkali-Hardened Leads

The tin-less, or low tin, lead-alloys, on which there is a large background of experience, are those hardened by small additions of alkali or alkaline earth metals. Grant [102] and Kühnel[93] have discussed in detail many varieties of such alloys, to which various trade names have been given. The compositions stated in the literature for any particular trade name have varied greatly, and the properties reported in any one investigation do not necessarily match those of any other very closely. Only the two most prominent of this family of alloys need attention. "Bahnmetall," developed in Germany, and "Satco," developed in the United States. The compositions of and hardness data for Bahnmetall and Satco were discussed in Part III.

Satco was formerly made at a rather high hardness level, but Hack[103] pointed out that modern Satco is now not so far above the hardness level of tin-base babbitt.

Bahnmetall has had its chief use on the German railroads and has been considered standard, and a satisfactory replacement for other babbitts, but Zunker[99] remarked in 1940 that it has not been found satisfactory in modern high-speed railway service, and that the German railroads were reverting to the use of tin-base babbitt for severe duty.

Handling the oxidizable alkali-earth and alkali elements in the foundry is not simple, and it is considered poor practice to have railway bearings using these alloys relined at any round-house; they are generally shipped to a central point where proper supervision and experienced workmen are available. The difficulty of control caused Satco to be given up for the making of steel backed bearings with thin linings on a production basis, after an extensive trial by one large maker of automotive bearings.

Bassett[104] points out that it is wise to segregate the production of alkali-hardened lead bearing metals from that of ordinary babbitts, since the contamination of the hardened lead with antimony from the ordinary babbitt leads to precipitation of antimony as alkali metal-antimony compounds.

It is reported[105] that Satco is in use in main bearings of relatively slow speed Diesels, such as those in the engines of some of the new streamlined railway trains. Underwood[98] says even Satco, with its content of 1 or 2 per cent Sn, is not immune to corrosion, which limits its use to low-temperature applications, or to uses in which non-corrosive oil is assured. Save for this drawback, he appraises it as the equivalent of standard tin-base babbitt, if used as thin linings.

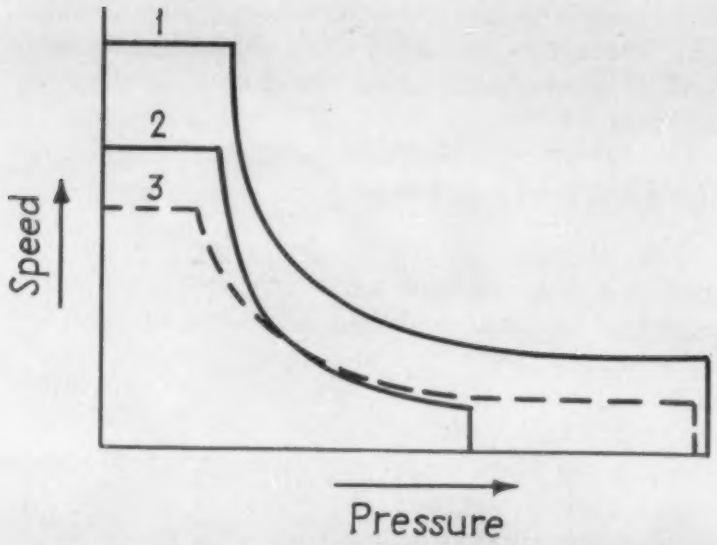

Fig. 21. Relative load-carrying ability. Kühnel[93]

1. 80 Sn, 12 Sb, 6 Cu, 2% Pb
2. 73.5 Pb, 15 Sb, 10 Sn, 1.50% Cu
3. Bahnmetall, 98.6 Pb, 0.7 Ca, 0.6 Na, 0.4 Li, 0.2% Al

Kühnel[93] gives Fig. 21 for the relative ranges of permissible speeds and loads for tin-base, regular lead-base and Bahnmetall bearings which indicates that, in his mind, Bahnmetall more nearly approaches tin-base than do the other lead-base alloys. Grant[102] says, of the alkali-leads, "these alloys will not carry as high loads nor function properly at as high speeds as will the best tin-base alloys."

Hack[103] points out that Satco starts to melt at about 560 deg. F. and to "wipe" at 520 deg., while tin-base babbitt (S.A.E. No. 11) starts to melt at 460 deg. and to wipe at 320 deg., so that Satco has a wider operating range. This advantage, however, may be nullified if the oil is corrosive to Satco at a temperature above the operating range of the tin-base babbitt.

Except for the greater propensity toward corrosion, the greater difficulty in controlling the composition on account of oxidation in melting, and the greater bonding difficulties, the alkali-hardened leads appear to be a step in advance over the usual lead-base babbits, and it is interesting to note that the improvement is accompanied by a hardness-temperature curve not very different from that for tin-base bearing metal. A lead-base babbitt, more corrosion resistant, more readily bondable and more free from oxidation difficulties in melting than Bahnmetall or Satco, and with a hardness temperature curve parallel to but above that for tin-base, (or, whatever its room temperature hardness may be, showing a hardness at operating temperature somewhat, but not too far, above that of tin-base babbitt), would be a boon. There may be hope of producing this, though Zunker's[99] efforts show that it is not likely to be attained with the use of the ordinary alloying elements.

At any rate, the alkali-hardened leads, in spite of their serious drawbacks, are available for a partial replacement of tin-base babbitt in time of necessity.

The Cadmium-Base Babbitts

A type of babbitt that more nearly meets the requirements for a super-babbitt exists in the cadmium-base group. As Fig. 19, Part III, shows, the commercial Cd alloys do have hardness-temperature curves roughly parallel to, and above, those for tin-base babbitts. Underwood[98] says they can be used in place of tin-base babbitt without changes in design or clearance. These cadmium alloys start to melt at about 600 deg. F., giving them a still greater temperature range than the alkali-hardened lead. Gilbert[106] shows that the cadmium alloys have higher seizure pressures than a hard tin-base babbitt.

Various laboratory tests, cited by Denham,[107] Heyer[108] and Underwood[98] indicate the cadmium-base alloys to be superior to tin-base alloys. The Cd-Ni and the Cd-Ag-Cu babbitts are used on the Ford floating bushing, where tin-base would be inadequate.

However, the experience with corrosion of cadmium babbitt on one year's model of the Pontiac several years ago, which ran hot, clearly showed that with oils that become corrosive through oxidation, the cadmium bearings do not have satisfactory corrosion resistance if the temperature is much above the usual temperature level for use of tin-base babbitts. To get around this difficulty, (and the analogous one with copper-lead alloys) many inhibiting addition agents have been proposed and patented to make oil non-corrosive. Ryan[109] suggested adding 0.1 to 1 per cent Sb to the Cd-Ag-Cu alloy to avoid corrosion, and Smart[110] suggested plating the bearing with indium and heat treating to diffuse the indium into the alloy, to make it corrosion resistant. The former suggestion seems to have been commercially adopted, but current advertising states that bearings in the White truck are indium treated.

If the melts are not handled correctly, the cadmium alloys dross badly in melting, but the bearing manufacturers understand how to overcome this, e.g. by the addition of a very small amount of zinc. The Cd-Ag-Cu alloy does not bond to steel as readily as the Cd-Ni,[110, 111] so a preliminary coating of the latter is usually applied before lining a bearing with the former.

When the cadmium alloys were first being developed, cadmium was not much more expensive than tin. As a demand for cadmium-base babbitt grew up, the supply was inadequate and even though bright zinc plating was introduced to replace cadmium plating, releasing more cadmium for use in bearings, the price continued to be much higher than that of tin. Hence the continued use of cadmium-base bearings is evidence that they are superior to tin-base.

So, to the extent of the available supply of cadmium, replacement of tin-base bearings is already in effect. As was pointed out in Part II, cadmium is a

by-product of zinc production, hence large extension of the use of cadmium as a replacement is not feasible.

The Copper-Leads

The usual recourse, when tin-base babbitt appears inadequate, is the copper-lead alloys. Since both these metals are cheap and neither are in the strategic group, ordinary economics, as well as strategic considerations, would appear very favorable to their development.

These alloys are difficult to handle so as to secure good dispersion of the lead, and doubly so when they are to be bonded to steel backs, since for bonding, long time of contact at high temperature, and for the proper structure, rapid freezing, are needed. These difficulties, and those connected with the necessity for high temperature due to the melting point of copper, make the finished bearing much more expensive than would appear on the mere basis of raw material costs. Seldom would the economics work out to make it advisable to replace tin-base babbitt where the latter will serve and is available. However, in case of tin shortage, some such replacement could be accomplished, although the copper-lead alloys are not in the babbitt class; they require harder shafts and greater clearance.

Various lead-base, tin-base and cadmium-base babbitts may be substituted one for another with only minor, if any, changes in the requirements for clearance, for shaft hardness, and for shaft and bearing finish. These babbitts all have conformability and embeddability in pretty much the same degree. This is well evidenced by the similarity of their hardness-temperature curves, Figure 19, Part III.

The hardness of the babbitts at 300 deg. F. ranges from perhaps 5 Brinell for a soft lead-base to perhaps 14 for cadmium-base, and they all show a gradual loss of hardness with increase in temperature. The copper-lead alloy, with a room temperature hardness not far different from that of the babbitts, has a Brinell of 20 at 300 deg. and if the Cu-Pb alloy is stiffened with 1 per cent Sn, the 300-deg. hardness rises to about 30. Probably because of the higher hardness at operating temperature, the Cu-Pb bearings are slow to wear in.

In the types of severe service to which Cu-Pb would normally be applied, precision machining and fitting is the rule, and the use of hard, well finished shafts is common. With increasing use of induction and flame hardening, the requirement of a hard shaft is not particularly onerous. However, the necessity for such shafts does limit the substitution of Cu-Pb for babbitt where babbitt now serves.

Notwithstanding that it was known that suitable shafts would increase the expense, and that the manufacture of Cu-Pb bearings is a tricky matter, it was thought, around 1934 to 1936, that a change to Cu-Pb would have to be made, in automotive practice, on the ground that babbitt has reached its limit of usefulness.

General Motors had plans for very large production, as described by Denham,[112] of a copper-lead which was to contain a little tin. Ford[113] produced steel-backed bearings with a cast-on alloy of about 30 to 35 per cent Pb, 1 to 1.50 per cent Ni, balance copper. Evans[114] said that Cu-Pb would eventually be the bearing used. Jenkins[115] also presented that point of view.

However, events did not occur just as predicted. With changes in methods of refining lubricants, it was found that the pools of lead in the Cu-Pb tended to be corroded by the new oils. Claydon[116] remarked that the oil industry was being asked to make Cu-Pb bearings possible. It is found, as Underwood shows, (Fig. 9, Part III) that sufficient additions of tin or antimony cure the corrodibility of lead, but when such additions are made to a Cu-Pb alloy the tin or antimony distributes between the copper and the lead. To get enough into the lead, too much goes into the copper, making the bearing too hard. Danse[117] pointed out a further drawback, saying that Cu-Pb is not a bearing metal, for it demands that lubrication never be allowed to fail for an instant.

The General Motors plans for wholesale production of Cu-Pb bearings were not carried through. By 1937 the difficulties attending the production and use of Cu-Pb bearings had become more plain. Thum[118] and others[119] commented on the change in trend of thought, and pointed out that while, two years earlier, Cu-Pb bearings were advocated for severe service like crankshaft bearings, the 1937 trend was to put them into less exacting service.

The need for greater clearance with Cu-Pb than with babbitt, the tendency of the tin-hardened Cu-(Sn)-Pb to score any but hardened shafts, the lesser ability of Cu-Pb to "run in" nicely, as well as the corrosion problem, had by that time been better understood. The necessity for hard shafts with Cu-Pb is brought out by Williams and Ludicka,[122] and is generally recognized.

In the absence of anything better, the Cu-Pb alloys came into some use for truck and bus engines, for Diesels, and for aircraft. Johnson[120] mentioned 26 to 31 per cent Pb, 1.5 per cent Ag, balance Cu, for aircraft use.

The Metallurgist[119] commented that in England Cu-Pb was not being used until it had been demonstrated beyond a doubt that white metal would not serve. McCloud[121] of Ford stated in 1937 that the proper chilling of Cu-Pb is very difficult, and that Ford had abandoned the Cu-Pb steel-backed bearing and substituted Cd-Ag-Cu or Cd-Ni in floating bushings. That is, a return was made to a bearing that is more of the type of tin-base babbitt.

Fischer[123] studied the Cu-Pb type of steel-backed

bearings, containing 17 to 42 per cent Pb, as supplied in 12 types or makes by five German manufacturers, in simulated bearing service on a bearing testing machine. He found that the majority of the bearings supplied were not satisfactory for highly stressed bearings because of failure by cracking and roughening of the surface. He remarks that the conditions for good bonding, high temperature and long time in contact with the steel before freezing, and those for good lead distribution, low temperature and quick freezing, make it difficult to achieve both purposes.

Swigert[124] comments that conformability and embeddability of the Cu-Pb type are not great, the bearings require accurate fitting, the anti-score characteristics are not great even in the straight Cu-Pb type, to say nothing of the Cu-(Sn)-Pb type. The advantages are higher thermal conductivity and the fact that the lead will melt out and act as a lubricant rather than the whole bearing melting out.

The consensus is that the high lead Cu-Pb type, as a bearing lining is extremely tricky and expensive to produce in spite of the low cost of the raw materials, and is only used because of lack of availability of something better. Compare the work of Herchman and Basil.[125]

Silver

Silver is a bearing metal which has a hardness level about like that of Cu-Pb with 1 per cent Sn and shows about the same hardness at 300 deg. F. as at room temperature.

Clements[126] and Underwood[98, 127] pointed out that pure, electroplated silver had friction properties much like those of lead, tin and cadmium. Its high melting point and great corrosion resistance make it of great interest.

Underwood classed it as standing above Cu-Pb in general behavior, far above it in fatigue resistance, and only handicapped by a somewhat erratic behavior as to seizure. To provide against seizure pure silver can be plated with a film of lead.[111] Or, it may be made very seizure resistant by the introduction of a little lead into the alloy itself. The history of this bearing, and its comparison with 71 Cu, 1 Ag, 28 Pb and 72 Cu, 3 Sn, 25 Pb, are given by Dayton.[128] Electrodeposited pure silver behaved finely against hard, polished shafts, but not so well against ground shafts. As was indicated in that report, and brought out in a later one[129] the addition of 2 to 3 per cent Pb made the bearing operate well against ground shafts.

Casting a fused 97.5 Ag, 2.5 Pb alloy on a steel back gives poor adhesion. Without the lead, fused pure silver can be bonded to steel. It is understood that certain non-ferrous alloy backings will accept the fused alloy to form a good bond. The Ag-Pb alloy can be electroplated,[130] the deposited alloy having as good bearing characteristics as the fused one. The plated Ag-Pb alloy does not appear to lose lead by corrosion.

Silver bearings are used in some very high output aircraft engines. Freedom from shaft deflection is necessary, since the silver is too strong to show conformability, but shaft hardness need not be excessive. Silver-lead should be a more widely applicable replacement for babbitt than copper-lead, and a far better material for severe duty, especially because of its high fatigue resistance. Silver is not a strategic material, but economics will require that as little be used as is really necessary, that is, that the silver lining be just as thin as will serve. This fact favors its application by electroplating.

Zinc Babbitts

There are other metals whose hardness and melting point might make them possibilities as bearing metals. Since cadmium is so good a bearing metal it would appear that zinc might likewise be, but the hardness of pure zinc, around 30 Brinell, is greatly increased by strengthening alloy additions, and pure zinc is said to be too prone to seize.

Kühnel[93] cites a considerable number of zinc-base alloys that have been tried in Germany and appraises them as suitable only for light service. This refers to alloys that resemble the bronze, rather than the babbitt, class. Bassett[104] mentions a Zn-Cu-Sn-Pb bearing with over 20 per cent Sn and 12 per cent Pb, which might be more like a babbitt and which is said to have given good results, but the tin content does not make this particularly interesting from the strategic point of view.

Magnesium and Aluminum

Magnesium alloys have been studied as bearing metals in this country without anything having been developed that appears ready for commercial use. Kühnel[93] discusses a few laboratory tests, including one on an alloy of 81 Mg, 19 Pb which had 50 Brinell at room temperature, 33 at 300 deg. F. The tests did not appear promising.

Aluminum alloys have come into some commercial use for bearings. Carpenter[131] long ago stated that 50 Al, 25 Zn, 25 Sn had excellent properties for certain types of bearings. Several types are marketed or offered for sale in Germany and are discussed by Kühnel[93] but the data are vague. For example one group called "Alva" has a Brinell hardness of "30 to 80 according to the type of service" and 9 different compositions are listed, among them 3 Pb, 3 Sb, 2 per cent Cu, balance Al and 5 Pb, 8 Cu, 3 per cent Fe, balance Al, so that tables and curves of properties for "Alva" do not mean much. The situation as to the groups of alloys under several other trade names is equally confused.

Bassett[104] appraises aluminum-base bearings, up to 1937, as not widely applicable, and confined to service under light loads, with good lubrication, and against hardened shafts. Kühnel[93] comes to about the same conclusions. However, Hives and Smith[133] state that Rolls Royce auto and aircraft engine big-end bearings are being made of Al, hardened with Ni, Mg, and with Cu or Sb and Si, and carrying 5 to 7 per cent Sn. These run 42 to 100 Brinell at room temperature and 36 to 90 Brinell at 300 deg. F. Fig. 22 shows comparative hardness values as given by Hives and Smith. The harder types demand very hard shafts (600 Brinell) and the softer ones, shafts that are moderately hard, 320 Brinell. These Al-Sn bearings are said to behave better than 70 Cu-30 Pb under starved lubrication. They appear to be used only as bushings, not as lined bearings, and probably require large clearance. Various workers have found the German aluminum-base bearings to require 2.5 to 3 times the clearance of babbitt or bronze, and emphasize the need of hard shafts. Pertmann[134] cites laboratory tests on an aluminum alloy with around 4 Cu, 1 Mn, 1.5 per cent Mg, of 80 Rockwell B, in comparison with a bronze of the same hardness, using the same clearance. He reports the wear rate, either dry or lubricated, to be about the same as on the bronze. He noted that the presence of 1 per cent Pb caused pitting and rapid wear. The alloy tested is used for spring shackle bushings and brake lever bushings.

Evans and Harrison[111] refer to aluminum bearings as aluminum-antimony alloys, and say that their difficulties have not yet been sufficiently investigated.

Considerable publicity has been given in metallurgical journals to "the use of aluminum bearings in Rolls Royce engines" which are said[135] "to have the bond and strength of silver, to run 23 times as long as babbitt and with lower friction, and with only a third the wear on the bearing as with copper-lead." The alloy is that described by Hives and Smith, containing around 6 per cent Sn with about 4 per cent of other hardening elements. The running clearance is given as 0.001 in. on the connecting rod and 0.0012 in. on the mains. The shaft hardness is 300 Brinell.

It is doubtful if this is actually used in the connecting rods of all high output Rolls Royce aircraft engines since it is stated[136] that the 1000 h.p. Rolls Royce Merlin engine uses lead bronze on mains and connecting rods against nitrided and lapped pins and journals. In fact, it is understood that the chief actual use of Al-Sn is in the main and connecting rod bearings of the small, Rolls-Royce made, Bentley automobile, and in the big ends of the other cars.

According to information from L. W. Kempf of the Aluminum Co. of America, supplementing his earlier article,[132] the best aluminum bearings contain from 5 to 8 per cent Sn with small amounts of other elements, as in the Rolls Royce alloys. They are used only as solid bearings, not as linings, and surface speed should be kept down, i.e., not over 3500 r.p.m. Carburized or surface hardened journals are desirable, with journals not smaller than 2 in. in diameter, and bearing clearances should be similar to those with Cu-Pb. Under these conditions very high loads can be successfuly accommodated, so that the bearings are coming into use in some truck, Diesel, tractor, and aircraft engines.

Thus it would appear that the aluminum bearings do not serve as direct replacement for babbitt bearings. Rather, they compete with Cu-Pb, and, from the strategic point of view, they require tin, which is all the more of a drawback because they are solid rather than lined bearings. Nevertheless, a large manufacturer of bearings is studying aluminum alloys intensively and considers that they have much promise but are not yet ready for general introduction.

It is not necessary to discuss the Bakelite type of plastic bearings used as rolling mill bearings, since their poor heat-dissipation characteristics prevent their use in any but a limited range. They are described by many writers.[137]

Thin Linings

Within its limitations as to temperature of use, tin-base babbitt appears more free from drawbacks than any of the substitute materials, especially when used as only a thin coating on a stronger back.

The use of a very thin coating, of the order of

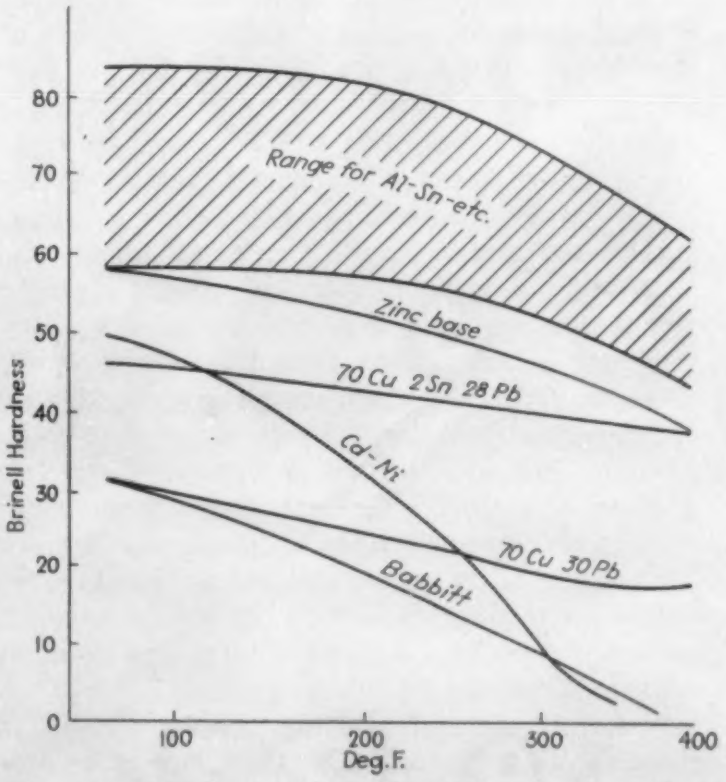

Fig. 22. Hardness of Rolls-Royce aluminum-base bearings. Hives and Smith[133]. Composition of Cd-Ni not stated, but probably 97 Cd, 3% Ni. Composition of zinc-base, "B.L.3," not stated.

0.0015 in. thick, is coming into commercial use. As the lining thickness decreases below 0.01 in., the life of the bearing increases very rapidly. The more it can be decreased, the less tin need be used in the lining, and the better the chances that a lead-base babbitt will serve instead of a tin-base. But such a thin coating, whether it be of tin-base or some other type of babbitt, brings in some fear that cases might be met where, say through warpage of the steel back, the finished bearing, lined by fusion methods, might have the backing completely covered to the eye, but the covering might be too thin in places. If at these places the lining is worn away or corroded away in service, the bare steel of the backing is presented to the shaft, which would favor seizure.

Triplex or "Sandwich" Bearings

In view of such possibilities, there is interest, as an insurance factor, in the interposition, between steel and white metal lining, of a material of intermediate properties, a material with some approach to the properties of a bearing metal, not quite so suitable for the active running face as is white metal, but less weak than white metal and decidedly less prone to score or gall the shaft than the steel backing. An early suggestion along this line is recorded by Roast [138] who says that for some years previous, a Scotch company had advocated a steel back, a leaded tin-bronze coating on it, and a babbitt top over the leaded bronze.

Such "sandwich" bearings are made, with the leaded bronze applied by casting, and the surface machined, followed by casting the babbitt and again machining. Some producers make the "sandwich" bearings by technique analogous to the old Ford method[113, 144] after which the babbitt is similarly cast on to the strip. There are several patents on applying a Cu-Pb coating by powder metallurgy and copper brazing methods. Shaw[139] indents a backing metal, "say copper," with fine pores or pits and metal-sprays pure tin or a tin-base babbitt upon the pitted surface. Laboratory tests are cited to show good seizure and friction properties, but no service tests are cited and no information given as to how the porous sprayed coating resists deformation under pressure. The scheme is of interest because it supplies an analog to a Cu-Pb bearing in which tin replaces lead but the mode of preparation is such that alloying of the copper with the tin is avoided.

The International Tin Research & Development Council is experimenting with electroplated tin upon "pitted" copper for bearings.

Portevin[140] speculates on the addition of unusual elements to Cu-Pb for use as the filling of a sandwich, to promote its adhesion to the steel back on the one hand and the adhesion of a babbitt facing to it, on the other hand. He recognizes that the problem is not a simple one.

Announcement is made[141] of a bearing for the 1941 Buick, claimed to increase bearing life 200 per cent over the steel-backed, thin-lined, lead-base babbitt bearing previously used. The steel back is coated, by powder metallurgy methods, with 60 Cu, 40 per cent Ni to form a porous matrix. The powder is compressed onto the steel strip, the strip and coating bonded together by copper-brazing technique, rolled smooth, put into a vacuum tunnel type chamber and when the air has been evacuated from the pores, a thin layer of lead-base babbitt (92 Pb, 4 Sb, 4 per cent Sn) flowed on. The coating is then machined down till the babbitt layer projects only 0.001 to 0.002 in. above the cupro-nickel layer, on the average, and leaves the high spots of the cupro-nickel layer, amounting to some 10 per cent of the area, bare to insure carrying the load. It is probable that these bare spots become smeared over with a very thin film of babbitt during wearing-in. The bearings are then stamped out and curved to the proper contour.

This corresponds to a steel-backed, Cu-Pb filled, babbitt-faced bearing, without the difficulties of bonding a molten Cu-Pb alloy to the steel, and has corrosion-resistant pools of babbitt in the matrix rather than corrodible lead. The lead pools and the filled voids in the cupro-nickel give some degree of comformability, and, of course, a relatively low modulus. The babbitt pools in the matrix are expected to prevent seizure even though the thin lining should be worn through. The hardness of the Cu-Ni-babbitt "filling" is not stated.

This manufacturing process contains several tricky steps, requiring special equipment, so it is obvious that the aim is bearing performance rather than cheapness.

Possible Equivalents

A somewhat similar combination of properties might perhaps be obtained without using three layers, for the back could be made of copper alone. By cold work, the Brinell hardness of copper can be varied between about 35 and about 100. By alloying the copper with about 0.03 to 0.10 per cent Ag, work-hardening can be retained to above 600 deg. F. (30 min. exposure), or to hot-tinning temperatures for the few seconds required to tin. With the lower silver content 200 days exposure to 300 deg. F. only lowers the hardness from say 70 to 60, with the higher, 150 days exposure to 390 deg. F. only produces a similar lowering.[142]

Copper-backed babbitt "snap in" bearings have been successfully run in an engine, replacing steel backed babbitt bearings,[143] with better behavior than the steel backs in freedom from cracking of the lining.

Swigert[124] remarks that sandwich type bearings are very expensive and difficult to manufacture, and

that a thin babbitt lining on a brass back, which has been commercially used,[144] has much of the advantages of the sandwich type. Neither brass nor copper ranks high as an anti-scoring metal, but either should do much less damage if it comes in contact with a steel shaft than a steel back would. Unexpected difficulties in bonding to the brass backs have removed that backing from present commercial use, though it should be possible to overcome the difficulties.

Swigert[124] echoes the statement that babbitt linings 0.002 to 0.003 in. thick give improved performance and longer life than thicker linings. The Buick lining is even thinner.

Plated Coatings

At such a range of thickness it becomes obvious that electroplating offers possibilities for competing with the standard coating methods, providing that plateable pure metals are proper bearing materials or that it is possible to plate a suitable alloy. If a still thinner layer is desired as a final facing over some other intermediate layer, plating comes still more into consideration.

Electroplating of alloys of the white metal group is possible. Cadmium plus a little silver can be plated out as an alloy of good bearing properties[145] and silver plus a little lead can similarly be plated.[130] This Ag-Pb alloy, electroplated on cast silver, has withstood almost twice the seizure pressure of the regular cast silver (+0.5% Cu) bearing.[129]

Thus, beside the fused linings of Pb-Sb-Sn which, if thin enough, can be substituted for tin-base babbitt in many uses; of Satco where corrosive conditions permit, which may be an even closer equivalent; and of the cadmium-base babbitts, which are not only equivalent but superior, the sandwich type bearings are coming into use. Beside the possibilities already explored, electroplated Cd-Ag or Ag-Pb linings can be applied over a suitable backing. Tin in the *thin* babbitt type of bearing thus is almost wholly replaceable. Fewer alternatives exist in rebabbitting old bearings with thick linings, where the present choice seems to be between Satco and the cadmium-base alloys.

Other Possible Backing Materials

While it is true that some of the materials would be difficult to plate upon, it is interesting to speculate on what might be done by combining other materials for bearing backs, either solid, or, where feasible, as a sandwich filling on a steel back with a plated or metal-spraying wearing and running surface. Such a surface layer should protect the sandwich filling from corrosion, so only the mechanical properties of the filling would be important.

Underwood,[108] who was obviously forecasting the 1941 Buick bearing, said that future materials must give greater fatigue life than the popular white metals, but must have their anti-score characteristics, they must be non-corrodible and not susceptible to injury by dirt or by shaft deflection. This order is hard to fill with a single alloy, but it appears that it can be filled by the sandwich type combination chosen by Buick, perhaps by others.

Purest aluminum, 99.9+ per cent, has a Brinell hardness at room temperature of about 15.[146] The hardness at elevated temperature does not seem to be on record, but Templin and Paul[147] show that very pure aluminum has 7,500 lbs. per sq. in. tensile strength at room temperature, which drops to 5,000 lbs. at 300 deg. F. This corresponds to about 10 Brinell. Thus very pure aluminum would have a hot-hardness curve like that of a superior type of babbitt. A duralumin back with a heavy coating of pure aluminum, similar to Alclad sheet, but with a heavier coating, with the aluminum surface plated with tin or with silver-lead might make a very interesting substitute for babbitt. As a coating for the running face, gold might be considered, since its hardness, 31 to 32, constant over the range room-temperature—300 deg. F.—is about that of silver. Experiments at Battelle indicate that an electroplated gold bearing surface, once well run-in, will thereafter have a high seizure pressure and hence should have useful bearing properties.

Anderson[148] cites Molinar as finding that annealed pure zinc and a 97 Zn, 3 Cd alloy have the following hot hardness:

	Room	160 deg. F.	250 deg. F.	340 deg. F.
Pure Zn	21	15	9	5½
97 Zn, 3 Cd	32	19	12	8

The Bureau of Standards[90] gives for annealed zinc, 99.99+ per cent pure, 31 Brinell at room temperature; 20 at 212 deg.; 13 at 300 deg. and 6 at 400 deg. F. While the cited values do not agree very closely, nevertheless it is seen that a pure zinc layer, which might be electroplated upon a steel back, should have a hot-hardness curve like those of tin-base or cadmium-base babbitts, and hence should have the proper conformability. Such a layer in a triplex bearing having a suitable corrosion-resistant and seizure-resistant plated running surface, should be another interesting substitute for babbitt.

Pure magnesium has[149, 150] a tensile strength of 24,000 to 30,000 lbs. per sq. in. at room temperature, corresponding to 30 to 35 Brinell, falling to about 20,000 lbs. at 212 deg. F., to 8,000 to 9,000 lbs. at 390 deg. F., which would correspond to about 10 Brinell. Because of this babbitt-like behavior, and its low modulus, magnesium should likewise be interesting when carrying a seizure-resistant coating, even though the metal itself may be prone to seize.

That is, besides the possibilities that have already been explored, there are still others that might produce bearings of babbitt-like characteristics without the use of tin. Fantastic as some of these may seem, a few of them might be worth exploring. Bearing behavior is, except for corrosion, more concerned with mechanical properties than with chemical composition, and it may be possible to engineer babbitt properties into the bearing without using any conventional type of babbitt.

As for corrosion, "save the surface, you save all," so a layer bearing might combine all the necessary properties.

Summary

To sum up, in the thin babbitt bearings, tin-base babbitt can be very largely replaced. New designs might often be engineered to take thin rather than thick babbitt linings. It is the thick linings and the re-babbitting of existing equipment that offer difficulties. For these, in spite of some drawbacks, the cadmium-base babbitts, insofar as cadmium is available, and Satco, can in a pinch be made to serve a considerable proportion of the cases. The triplex bearings offer possibilities that are worth more study, with a plated silver-lead coating indicated as very advantageous for the running face. Copper-lead can be resorted to in some cases where babbitt is now used, but it entails many difficulties, both in production of the bearings, of shafts of proper hardness, and in providing that lubrication always be uninterrupted.

The tin bronze bushings offer more of a problem. Probably our old friend 85-5-5-5, which can be made from scrap, would do in a good many cases where higher tin alloys are now specified. Sometimes the aluminum bronzes can be resorted to. The zinc-base alloys may also be worth resurrecting.

At any rate the bearing industry could keep the nation's wheels turning with far less tin than is normally consumed for that purpose. But considering the difficulties that have had to be overcome in finding other materials as good as "genuine babbitt," one has considerable respect for Isaac Babbitt, who more than a century ago, in U.S. Patent 1252 of July 12, 1839 mentioned as "an excellent compound" one of 89 Sn, 9 Sb, 2 Cu. It is still excellent, and as long as tin is available, we will continue to use it, or one of its near relations. It would indeed be an inconvenience to have to get along without tin for bearings. But if the bearing industry can't get tin, it *can* get along quite nicely without very much of it.

Added Note

An advertising folder, put out by a German firm, and enclosed with a September, 1940, issue of *Stahl und Eisen,* discusses the shortage of Cu and Sn in Germany on account of the blockade and advocates centrifugally cast bearings of the familiar die casting alloy 4 Al, 1 Cu, trace Mg, balance 99.99 per cent pure Zn, of 90 Brinell, as a substitute for bronze bearings. Amsler wear tests are cited at 50 kg. per sq. cm. to show that wear is practically identical with that of an 80 Brinell bearing bronze, though tests at 100 kg. per sq. cm. gave rapid initial wear of the Zn alloy. From this it is argued that with very smooth finishing and careful running in, the Zn bearings can be used under average conditions, when speed and pressure are not too great. Initial clearance, it is stated, may be the same, since the greater initial wear of the Zn bearing compensates for its higher thermal expansion! It is admitted that the corrosion resistance is only about that of Zn. The claim is made that bearings are the most important field for application of Zn alloys.

Correction:

The caption accompanying the fourth photograph of the second installment of this series of articles, on page 461 of the October 1940 issue, was erroneous. The machine illustrated was the General Motors bearing tester, while the caption referred to the Pratt & Whitney bearing tester. Photographs of the Pratt & Whitney machine have appeared in an earlier issue of METALS AND ALLOYS (page 69 of the March 1940 issue, in an article by Mr. E. A. Ryder) and will not be reprinted at this time. A description of the General Motors machine is given on page 462 of the October issue, under a drawing of that machine.

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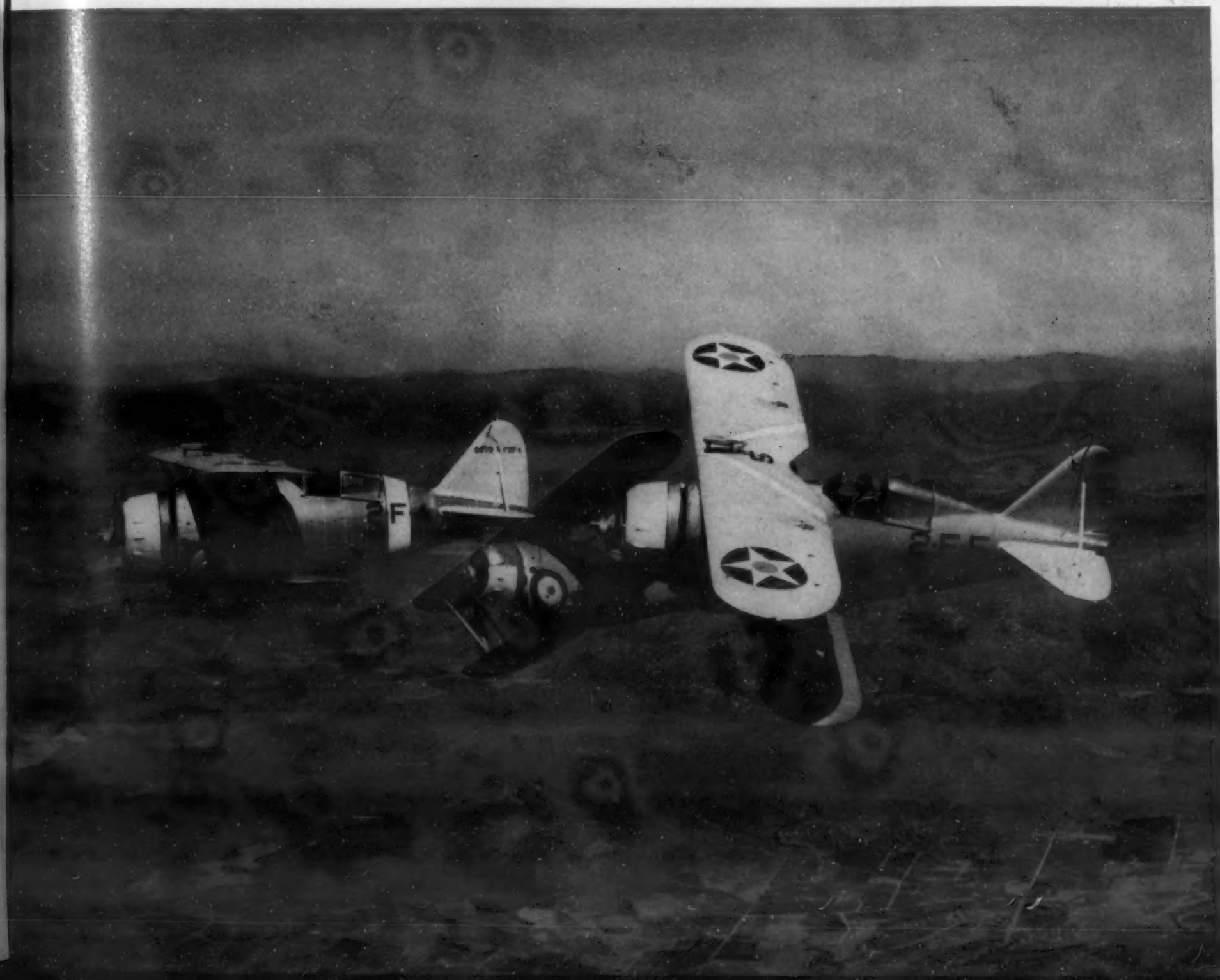
(Continued on page 768)

Metallurgical Engineering

In Preparedness and Defense

Continuing our series of articles on Metallurgical Engineering in Preparedness and Defense, to which the entire October issue was devoted and also a small portion of the November number, we present in this issue three more discussions. . . . Highly essential are supplies of aluminum and magnesium to the Defense Program. Two authorities in these fields review the situation on the following pages. . . . The relation of the American Iron and Steel Institute to the Defense Program, particularly with reference to its technical committees, is discussed by the secretary of the Institute's Technical Committee. . . . For illustrations in this section we are indebted to the U. S. Army and Navy at Washington, D. C.—The Editors.



Aluminum and Magnesiu

and National Defense

HIGHLY ESSENTIAL *but not strategic are both aluminum and magnesium in the National Defense Program. They are vital materials in aircraft construction.*

We present in the two following brief articles a discussion of the present status of these metals by authorities in those respective fields.

Aluminum is reviewed by Dr. Colin G. Fink, head of the department of electrochemistry, Columbia University, and secretary of The Electrochemical Society. Magnesium is discussed by L. B. Grant, Dowmetal sales manager, The Dow Chemical Co., Midland, Mich.

Aluminum

by COLIN G. FINK

Since 1919, the world's output of aluminum metal has doubled every 10 years. This is primarily due to the rapid growth of large-scale applications of aluminum. Thus, in the production of airplane propellers, crank cases and landing gears, many thousands of pounds of aluminum metal are consumed. Another significant outlet for aluminum metal is in transmission cables of which there are almost 900,000 miles in use in this country alone. Germany has gone so far as to use aluminum cable sheathing in place of lead.

Fully realizing the importance of aluminum in aircraft construction, Germany early in 1933 started upon an intensive production campaign. Existing plants were enlarged and new plants added so that by 1939 Germany's production rate had increased tenfold, attaining 200,000 metric tons of aluminum per year as against 150,000 tons for the United States, the foremost producer of aluminum for many years.

The consumption of aluminum in Germany in 1939 was tenfold that in 1932 and almost fourfold that of the rest of the world.

These figures emphasize the importance of aluminum in the Nazi war machine. The figures become all the more striking and significant if we take into account that the raw material for aluminum, bauxite, was not available in Germany and had to be very largely imported from Hungary, Jugoslavia and elsewhere. The extraction of aluminum from clay has been experimentally investigated in Germany but has not attained commercial status—especially not now when Germany is in possession and control of one of the world's best bauxite deposits, that of France.

Here in America aluminum is not a strategic metal, but it is a most essential war metal. Fully cognizant of the dominant position of the airplane in modern warfare, the Aluminum Co. of America over a year ago initiated a very comprehensive plan of plant and metal output extension. There is every indication that the United States production for 1940-1941 may exceed that of Germany for that period. The Aluminum company's program involves an expenditure of almost $60,000,000. Of special significance is the new reduction plant now under construction at Vancouver on the Pacific coast with a rated capacity of 15,000 tons of aluminum metal per year. Alabama bauxite will be used and Government hydroelectric power from the Bonneville Dam.

The chief bauxite-producing state in the United States is Arkansas. The Bureau of Mines reports a 1939 output of 361,000 metric tons, valued at $2,166,000. The United States imported bauxites, largely from British and Dutch Guianas, totaling 520,000 metric tons. This, together with the domestic output, brings the 1939 supply to approximately 900,000 tons of bauxite.

Canada possesses one of the largest aluminum plants of the world, located at Arvida. A second large plant is at Shawinigan Falls. Canada's aluminum metal production in 1939 totaled 75,000 metric tons or about half that of the United States. About 96 percent of Canada's output was exported. Canada's aluminum output per inhabitant far exceeds that of the United States. Canada has no bauxite mines. All of the raw material is imported from the Guianas and elsewhere. Significant is the proximity of the unique cryolite deposits of Greenland. It will be recalled that the fused salt bath used in the electrolytic production of aluminum is a fluoride, or modified cryolite, bath.

As to "conservation of aluminum," this is a problem we approached a few years ago in our laboratory. We discovered that, under properly chosen conditions, firmly adherent deposits of aluminum on steel and on other metals are easily attainable. The new product, "Alplate," is now being produced commercially at Louisville, Ky. Aluminum-coated steel is flexible and ductile, it is highly resistant to fatigue, corrosion and elevated temperatures. Alplate can be kept at 1000 deg. C. for 1000 hrs. without destroying its ductility.

Magnesium

BY L. B. GRANT

The National Defense Program has turned the spotlight on magnesium as an indispensable material for military preparedness. Consequently the domestic production of this remarkably useful metal suddenly becomes a matter of special importance.

When an American method for producing magnesium was developed 25 years ago, the purpose was to provide industry at large with a low-cost domestic supply. With this source available at prices no longer prohibitive, new uses were found, new markets were opened. Magnesium came into its own and is now regarded as vital in a great variety of industries, from units of transportation to portable tools and business and household appliances.

Naturally production was greatly increased to meet these growing uses, but was always equal to demand. Now the tables are turned.

The present tremendous demand for magnesium was brought about by two conditions that have occurred simultaneously. First, as a result of years of research, education and service trials, magnesium has recently gained a much wider acceptance by engineers and production men as an excellent material for light weight construction, particularly for aircraft.

Second, the airplane has suddenly come to the front as one of the most important factors in defense equipment and airplanes are now being made in quantities that seemed impossible only three years ago.

This combination of circumstances is increasing the consumption of magnesium at a terrific rate.

The resulting temporary shortage of magnesium metal has inspired questions in some quarters. What are the reasons for this lack of availability to meet the special requirements that suddenly developed? Why, for example, did domestic production, until recently, reach only 12 million pounds a year while a European country is producing something like 38 million pounds a year?

There is, of course, nothing sinister in this situation. As a matter of fact the comparisons are unfair. For it must be remembered that we in America are operating under a system of free enterprise. Industry increases its plants and facilities as it increases the demand for its products. It must first get its markets and its business is carried on under the conditions of open competition. Under the totalitarian regimes abroad, there are no such conditions or limitations. The government tells industry what to make, when, where, how much, and for what purpose.

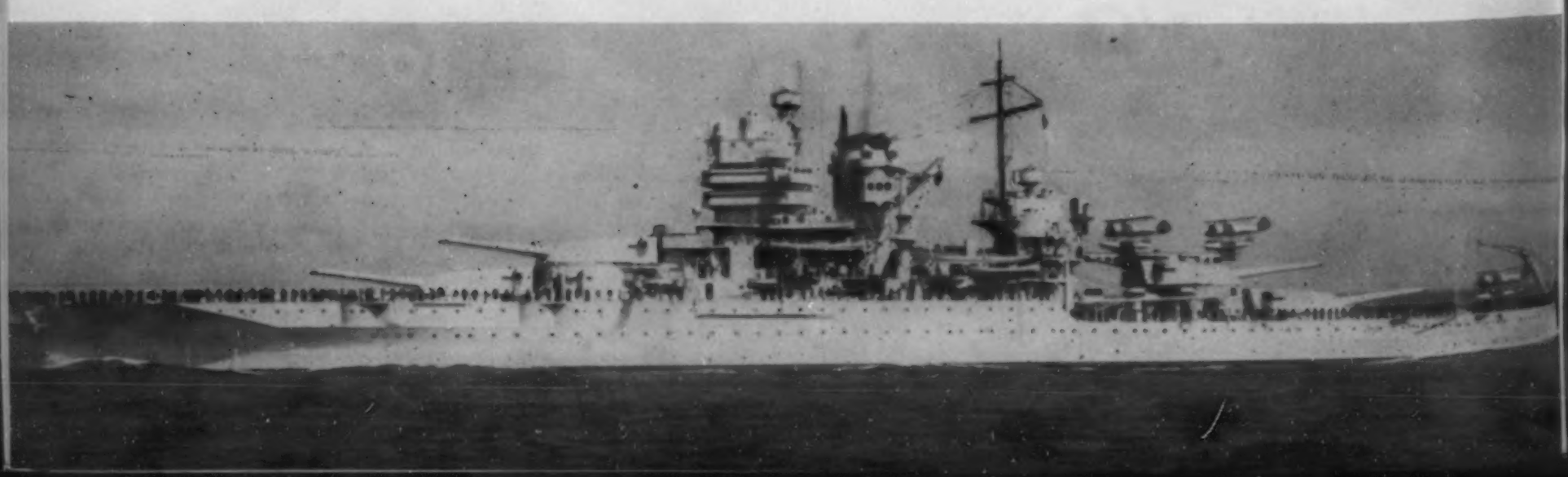
It must be remembered also that magnesium production plants can no more be multiplied over night than can plants for the manufacture of gun powder, tanks, airplanes and other defense equipment.

The magnesium industry, however, was not caught wholly unprepared for the emergency. It foresaw the trend of events and, without Government aid, took steps over a year ago to get ready for a rapidly expanding demand. Within the past year, the output of magnesium metal was doubled and within the next few months will be doubled again. Foundries and shops in many parts of the country have been expanding rapidly to produce the manufactured articles of magnesium and magnesium alloys which are necessary for military preparedness.

A few statistics, compiled from the annual "Minerals Yearbook," published by the Bureau of Mines, will furnish a quick survey of the growth of the magnesium industry in the past 10 years, in which steady but unspectacular progress was made until the last year when increasing demand, largely due to the war in Europe, brought about a sudden unsweep in the sales figures. The data follows:

Year	*Primary Mg Sold or Used, Lbs.*	*Structural Products, Lbs.*	*Non-Structural Products, Lbs.*
1930	559,631	114,464	38,730
1931	580,463	163,970	26,830
1932	791,699	189,122	24,475
1933	1,434,893	325,706	40,528
1934	4,249,838	546,018	88,165
1935	4,241,218	574,039	99,917
1936	3,903,312	975,640	66,386
1937	4,539,980	1,418,391	100,667
1938	4,819,617	1,278,370	184,223
1939	10,650,121	2,356,260	232,244

In the earlier years of the decade the structural uses of magnesium alloys were in relatively small amount. These called for sand castings, die castings, extruded shapes, sheet, and forgings. The non-structural uses were supplied by ribbon, wire, and powder. The bulk of the output was accounted for by magnesium used as deoxidizer in non-ferrous metallurgy and as a minor constituent of aluminum and other alloys, and by that sold for export.



Structural uses increased at a gradually accelerating rate, although they did not exceed 1,000,000 lbs. a year until 1937. Non-structural uses also increased. During the whole period until 1939 production of primary magnesium was well in excess of demand and reserve stocks were accumulated. These stocks were drawn on in 1939, when for the first time the demand exceeded production.

As the sole producer of primary magnesium in the United States, the Dow Chemical Co., steadily increased its output to keep ahead of demand. In 1939, its plant capacity had grown to 6,000,000 lbs. annually. In that year it met the suddenly increasing demand by a building expansion which doubled its annual capacity to 12,000,000 lbs. beginning in February, 1940.

As this expansion was not sufficient to keep up with rising demand, plans were at once made for the construction of a new plant at Freeport, Texas, to double again the company's output to 25,000,000 lbs. annually. Construction of the new plant was commenced in March, 1940, and it is now nearing completion.

The Dow Chemical Co., holds no monopoly on the production of magnesium because the supply of magnesium bearing ores and brines are abundant and widespread and many processes have been discovered to produce the metal from these ores and brines.

It is also worthy of note that the price of magnesium metal is now $0.27 per lb. which contrasts significantly with $3.50 per lb. which American industry was paying when The Dow Chemical Co., entered the field in 1915. This reduction in price has been brought about by constant development and refinement of processes as well as by the lower costs of larger production. It is felt that the present price for magnesium metal is in no way a hindrance to its further development and that it compares favorably on a cost basis with other light weight materials of construction.

The patent situation with respect to the production of primary magnesium and its fabrication into useful articles has been the subject of recent comment in the press, much of which has been erroneous and without basis in fact.

The process employed by The Dow Chemical Co., for the production of primary magnesium, which involves the electrolysis of magnesium chloride in a fused salt bath, has been developed by the company through its own efforts without dependence upon foreign patents. The operations of the company are protected by its own patents and it has no licenses under patents on magnesium metal production owned by others. This enterprise is solely an American development which owes nothing to foreign interests and has no connection with them.

In the fabrication of finished articles from magnesium alloys there are numerous United States patents not owned by Dow. In order to further the advance of magnesium fabrication in this country, Dow has secured licensing rights under a large group of these patents, and has made them available to the industries without royalty. There is nothing in the patent situation which has hindered or held back the growth of the magnesium industry in this country.

In fact, it is believed that these licensing rights have aided fabricators by removing restrictions on the use of foreign processes covered by these United States patents.

The doors have been opened to American industry. Acceptance of magnesium by engineers and production men is now enthusiastic—especially so in the industries manufacturing defense equipment. So from now on a much larger and more widespread use of magnesium alloys is to be expected.

The need for larger production of magnesium arises now mainly from the airplane building program. Because magnesium alloys have a higher strength-weight ratio than other structural metals, they are essential in airplane construction. In general the development of magnesium alloys for structural uses has paralleled the growth of the aircraft industry. These alloys are constantly being adopted for new uses in airplane construction.

At present the principal requirements are for sand and die castings. Parts for which castings are used include crankcases, blower sections, accessory housings, pump bodies, landing wheels, door and seat frames, levers, pedals, instrument cases, and other parts. Application is being made of sheet metal and extruded shapes for cowling, fairings, moldings, and similar parts.

Non-structural uses of magnesium for military purposes are of older application, and were extensively employed in World War I. In the form of ribbon or powder, magnesium is used in large quantities in flares and tracers, where its chemical properties of igniting and burning at high temperature with the emission of brilliant light and heavy smoke fumes are utilized. For such purposes magnesium has long been recognized as an indispensable material.

For the production of magnesium alloy castings over 30 well-equipped foundries are located in the chief consuming areas, mostly in the East, Middle West and Far West. These foundries are prepared to supply the intricate castings required for many aircraft parts, and are sufficiently decentralized so that bottlenecks are less likely to occur.

Sheet metal, extruded shapes and tubing are produced by The Dow Chemical Co., at Midland, Mich., and by the American Magnesium Corp., at Cleveland. The facilities of the various fabricators of magnesium are being expanded as rapidly as circumstances permit to supply the additional requirements of structural parts of magnesium alloys for use in connection with the preparedness program.

The Technical Committees of the American Iron and Steel Institute

by CHARLES M. PARKER

Secretary, General Technical Committee, Amer. Iron and Steel Institute, New York

To round out our series of articles on Metallurgical Engineering in Preparedness and Defense, inaugurated with our October issue and continued on a smaller scale in our November and December numbers, we asked the American Iron and Steel Institute to discuss the relation of certain activities of the Institute to the Defense Program.

In this article the activities and the relation of the technical committees of the Institute to this Program are illuminatingly discussed by the secretary to these committees.—The Editors

ACTIVITIES OF THE TECHNICAL COMMITTEES of American Iron and Steel Institute have been given new point and purpose by the National Defense Program.

In armaments and munitions, several kinds of steel products which are almost unknown in everyday commercial use are required in large tonnages. On the other hand, the regular steels of commerce likewise play a large part in equipping land, naval and air forces for successful action.

To supply the defense forces of the nation with the proper materials on a carefully timed delivery program is a task which requires a vast amount of technical knowledge and an intimate familiarity with the many producing units of the steel industry. The several technical committees of American Iron and Steel Institute qualify eminently for assisting in that task.

The Institute's Technical Committees

The technical committees of the Institute began to function about seven years ago. During the period when the National Industrial Recovery Act was in force, it became apparent that there was a good deal of confusion within the industry as to the precise meaning of technical terms, the correct interpretation of provisions of widely used specifications and other related technical details. As a result of that experience, the original Technical Committee, composed of chief metallurgists and inspection engineers of a number of representative companies in the industry, started in to compile a "Steel Products Manual," which would dispel some of the confusion that had been experienced.

As time went on and various sections of the "Steel Products Manual" were compiled and published, there appeared a need for more precise information on operating details than are ordinarily known to metallurgists and inspection engineers. Accordingly, a Committee on Manufacturing Problems, composed of operating executives, was formed. That committee was charged with the duty of investigating and considering such matters of general interest to the industry relating to manufacturing problems as may from time to time come to its notice or be referred to it.

In the beginning that committee studied a variety of problems of interest to both consumer and producer, ranging from the so-called hydrogen evolution test for tin plate to a study of oil and water line pipe sizes in the field of tubular products. In addition, members of that committee discussed and exchanged data on such subjects as: Standard methods of chemical analyses for steel products; standard methods of reporting rolling and heat-treating temperatures; calibration of pyrometers, carbometers and other precision instruments; methods of grain size control and the like.

Classification of Types of Steel

A natural outgrowth of the studies conducted by both the Technical Committee and the Committee on Manufacturing Problems was a study of a possible new classification system for all types of steel. To pursue that study those two committees found it necessary to join forces and to secure such detailed technical information as off-heat expectancies of various carbon and manganese ranges, the relationship of ladle analysis to check analysis, and tonnage distribution of steel qualities by products. The latter item alone involved an intimate study of many thousands of orders.

A similar study was undertaken with respect to pig iron. The need for such a study is apparent when it is known, for example, that some producers of merchant pig iron find it necessary to maintain stock piles of more than 1,000 different analyses. The investment involved, not only in iron but also for space in which to store it, is an appreciable factor in costs. It was hoped that through such studies it might be found practicable to lessen materially the number of different steel and pig iron compositions which are specified by consumers and to concentrate research and development work more actively on those compositions and types which are most widely used.

The burden of work involved in such an effort was tremendous, and because of that and the precise technical knowledge required successfully to prose-

cute such a study, it was found necessary to form technical subcommittees, each of which could devote its entire energies to the study of one product, or at the most of a very few related products.

To that end 16 technical committees were formed to study products ranging from forged axles, pig iron, plates and structural shapes to drawn wire and cold-rolled strip steel. Other committees are studying problems relating to packaging, loading and shipping steel products, and are actively working on standard specifications for: Wrapping papers; slushing oils; bundling ties; methods of packaging, loading and bracing flat rolled materials in both sheet and coiled forms; and standard nomenclature of terms used in the loading and transportation of material.

The original Technical Committee, now known as the General Technical Committee, serves as a co-ordinating body for the several technical subcommittees and acts as a liaison among metallurgical and chemical interests on the one hand and operating interests on the other.

Committee on Government Specifications

Recently there has been appointed a Special Committee on Government Specifications charged with the duty of assisting the many agencies of the Gov-

ernment in the drafting of and interpretation of specifications for steel products. That committee, which is composed principally of metallurgists, has acted in an advisory capacity on problems involving ferroalloys, shell steel, light armor plate, hull steel, shell crate steel, airplane forgings, airplane antenna wire and many others.

The members of that committee, although actively engaged in their regular jobs, are pledged to act unselfishly and for the benefit of the Government, and the steel industry as a whole. At their command are the several regular technical subcommittees which furnish them with precise and detailed knowledge pertaining to specific problems with which they are asked to deal.

Probably the most important work now being done by the several technical committees is that relating to the classifying and coding of steel and pig iron compositions which are in greatest demand.

The ever-growing variety of chemical compositions and quality requirements of specifications for steel have for years been a matter of concern in the steel industry. That condition prompted the General Technical Committee to conduct a survey with a view toward simplifying the problems of both consumer and producer by searching out those grades of steel in most common demand. Another purpose of the Committee was to combine specifications having like requirements and to collect and compile information concerning the relation of the more common grades to the many purposes for which such steels are used.

Two Definite Groups of Steel

That survey showed that, exclusive of stainless steels and tool steels, several thousand different combinations of chemical elements were being made to meet the individual demands of purchasers of the primary rolled and forged steel products used in American industry. The survey showed, too, that these manifold grades of steel naturally divided themselves into two groups from the standpoint of volume of demand. One group embraced those grades that were ordered in large tonnages, the other those grades that were ordered in relatively small tonnages.

The larger quantity group, comprising about 200 grades of carbon and alloy steels, amounted to more than 94 per cent of the tonnage of the principal steel products manufactured in the years 1937, 1938 and 1939.

The facts thus developed have convinced steel producers that, if their efforts could be concentrated upon a limited number of standardized grades, deliveries could be expedited and service improved. Moreover, there would be a better opportunity to achieve advances in manufacturing practices and quality and to study more fully the possibilities of application inherent in those grades.

Other problems of vital interest to industry are being studied in one or more of the technical committees and their services are in many cases extended to technical societies, and others, for cooperative effort. Joint research in the interests of railroad safety is now under way at several steel plants and at the University of Illinois in conjunction with the Association of American Railroads. Designs of passenger car axles are being studied, new designs have been formulated and tested, and heat treatment procedures for rails have been investigated and improved. Problems of design and improved materials for wrought steel wheels are being studied to meet the ever-increasing loads and speeds of fast freight and passenger trains.

In the field of structural materials the use of heavier steel structural shapes is well established on a sound technical basis, but the development and acceptance of the lighter-steel structural members, such as those formed from light-gage, flat-rolled steel, have been retarded, because there is no such recognized basis on which to establish their use, although it is known that thin steel members behave differently under load from the heavier conventional steel shapes.

Committee on Building Codes

The development of basic engineering and technical data relative to light steel members is essential to the acceptance of such members by building code and other specifying authorities and to their broader use. In this connection, the following activities have been undertaken under the direction of a Special Committee on Building Codes appointed by the directors of the Institute.

(a) Research investigation at Cornell University is being carried on to determine the behavior of light-gage steel beams under load, and is developing very valuable information relative to the proper design limitations of such members.

(b) Investigation relative to steel-stud wall construction has recently been started at Cornell to develop standards of design for steel studs and collateral materials used in wall construction.

(c) Various fire tests and load tests have been made at the Bureau of Standards, at Ohio State University, and at laboratories of manufacturers.

Information and specifications developed through those investigations and tests have been supplied to the National Advisory Committee on Aeronautics, and to the Army and Navy in connection with the national defense program.

The increased use of welding has necessitated research in both materials and technique, and comprehensive investigations are now under way at Battelle Memorial Institute in conjunction with the Welding Research Committee of The Engineering Foundation.

(Editorial continued from page 733)

gradation of 18:8. Proper study of the relation should evolve a particular type of 18:8 especially fitted to handle fatigue problems. The effect of additions for free-machining also needs to be studied from the fatigue angle.

The producers of 18:8 are strangely lacking from the list of those who have presented the most useful data on the suitability of the material for fatigue service, probably because potential users have not been sufficiently insistent in their demand for data.

The virtues of the material, already apparent, justify its classification as high in the list of fatigue-resisting alloys as in that of corrosion-resisting alloys.

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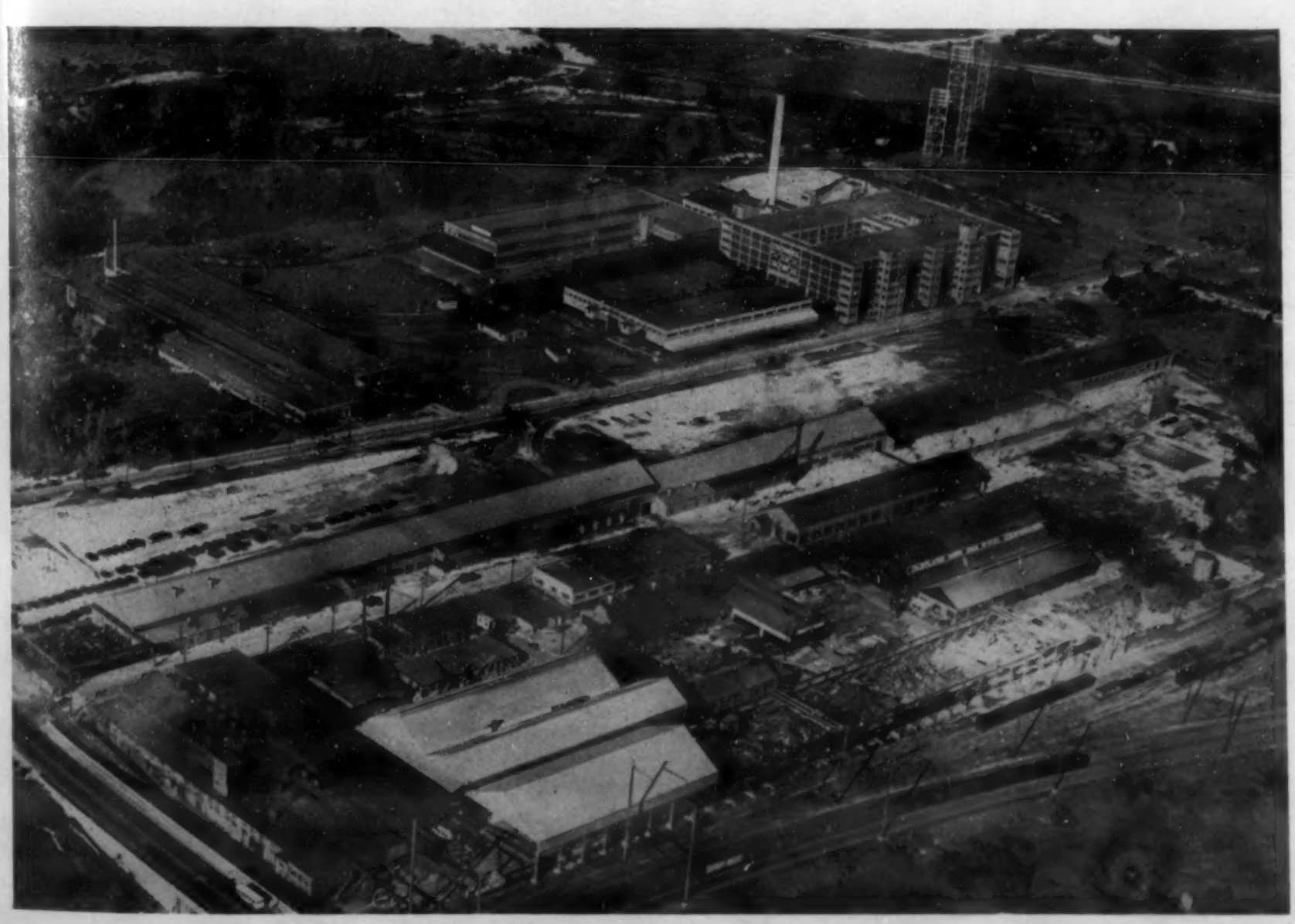
Plant Expansion of the Rustless Iron and Steel Corp.

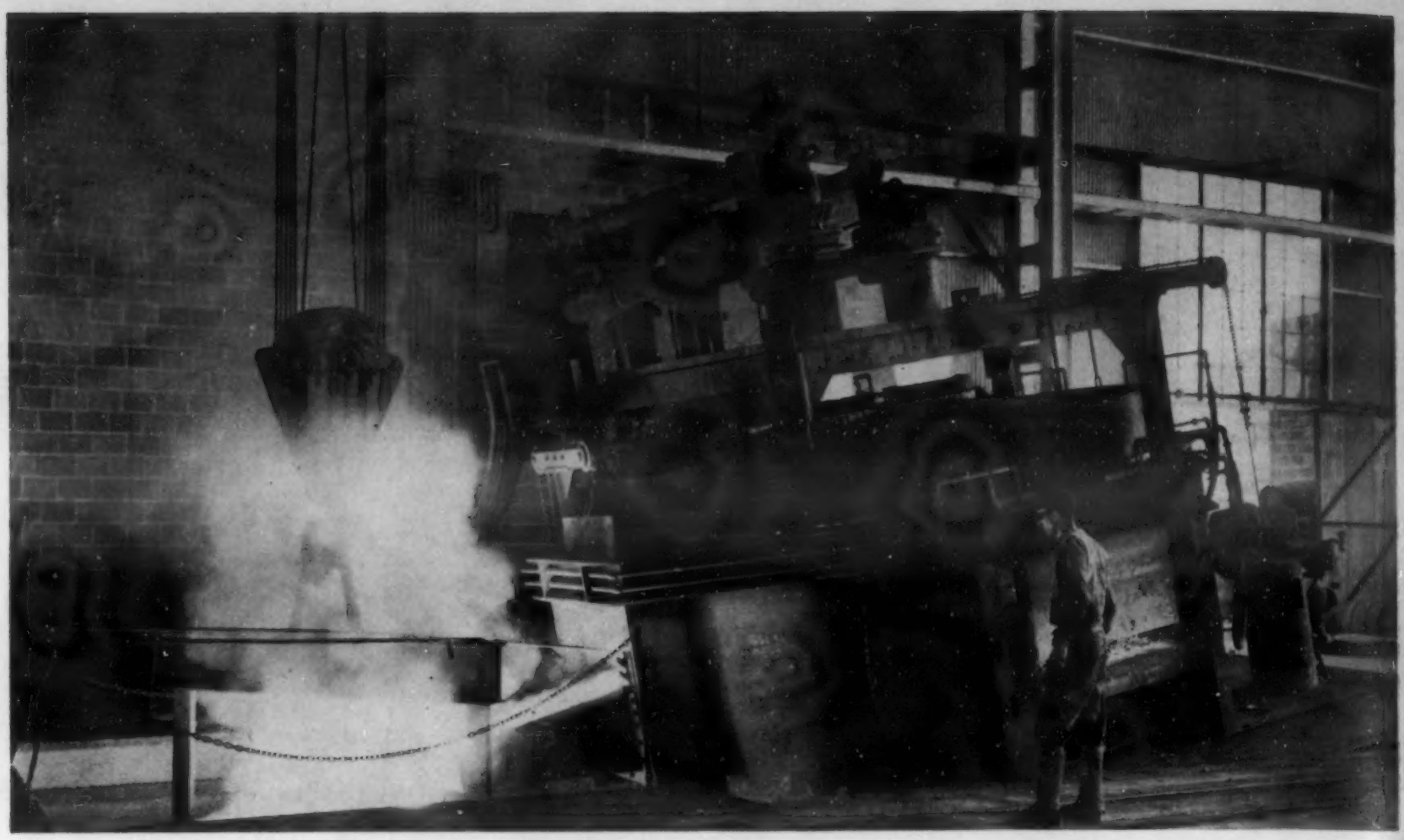
by Edwin F. Cone

ONE OF THE MOST STRIKING developments in the American steel industry in the last 25 years has been the growth of the stainless steel industry. From very small beginnings in the early years of this century, the production of this grade of steel has grown to substantial proportions. Several American steel companies share in this development but there is one large company which, from its inception, has devoted all its energies and talent exclusively to stainless—the Rustless Iron and Steel Corp. of Baltimore, Md.

In 1935 the management of this company inaugurated an expansion program,

Airplane view of the Rustless plant at Baltimore as it appears today. In the structure under 3 roof levels through the center of the picture is housed the new 1,800-ft. straight line production set-up.





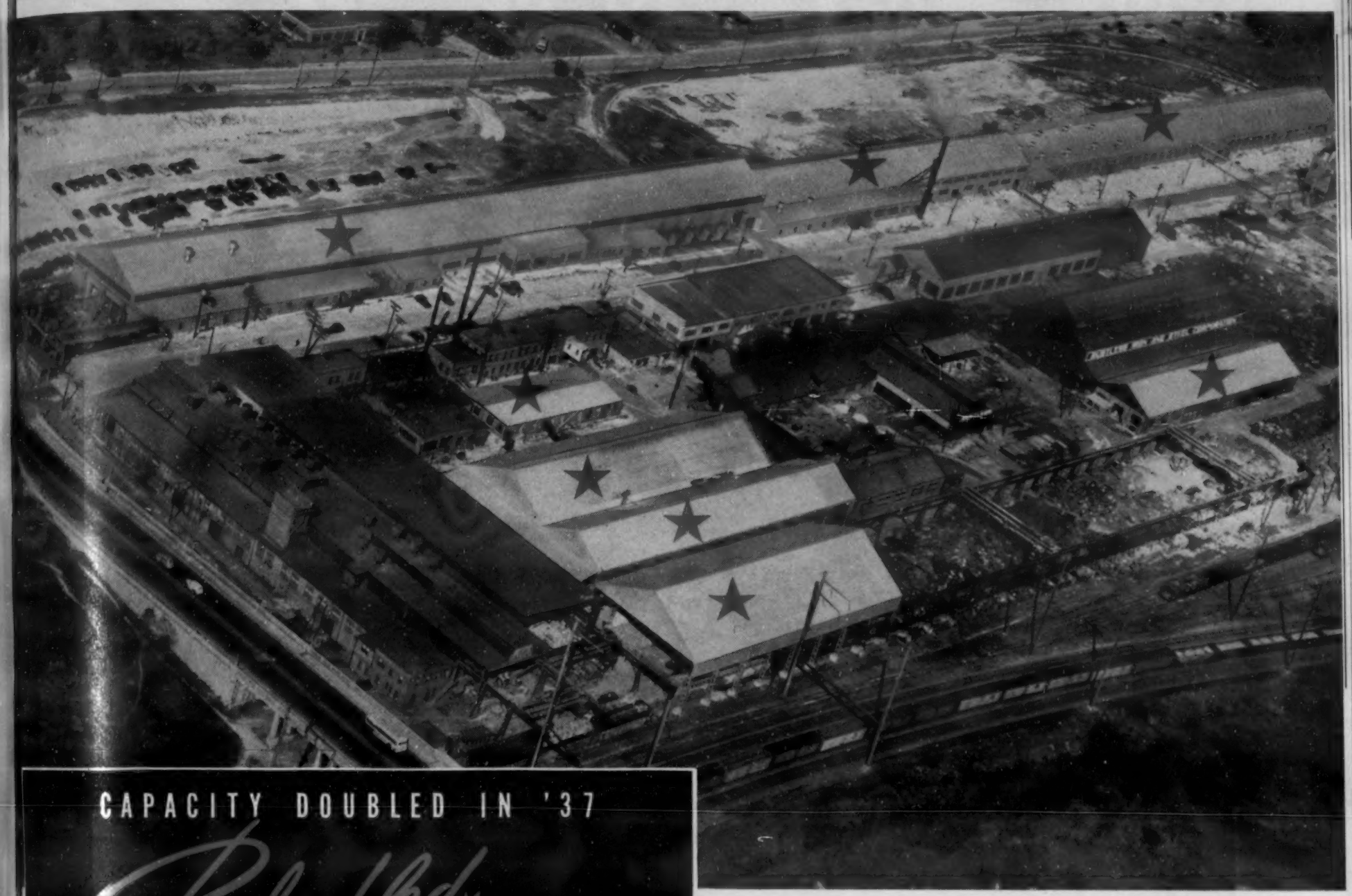
Tapping one of the 5 electric arc furnaces in the melt shop. This type of furnace is used because extremely close control of temperatures and of chemical reactions is essential in making stainless steels.

intended for long-range accomplishment. In celebration of the completion of a large part of this program—the building of a new $2,500,000 addition, modern in every respect—the company on Nov. 8 gave an open-house inspection to over 500 steel executives, stainless steel fabricators, jobbers, financiers, representatives of the technical and daily press, and others.

Visitors at this open-house inspection were taken through every department and had an opportunity to see the Rustless process of stainless steel manufacture which is described as unique since the main feature is the use of virgin chromium ore,

A specially designed charging machine withdraws hot ingots from the heating furnaces and transfers them to the 28-in. mill table at right center.

RUSTLESS



CAPACITY DOUBLED IN '37

Redoubled TODAY

Compacted to a five-year period by pyramiding market demands, the "long-range" expansion program launched by Rustless in 1935 has already been completed.

Every step in the production of stainless steel bar and wire, from reduction of ore to special finishing operations, is carried on here. Straight-line production methods accelerate the movement of material, while permitting the continuous supervision and exact control that are essential. All equipment is new or completely modernized, and is specifically designed for one job and one only—the making of finer stainless steel.

The enlarged plant permits us to meet the needs of both old and new customers for increased quantities of stainless steel, while still maintaining the standards of quality and uniformity that have built our business. We will welcome the opportunity of serving you.

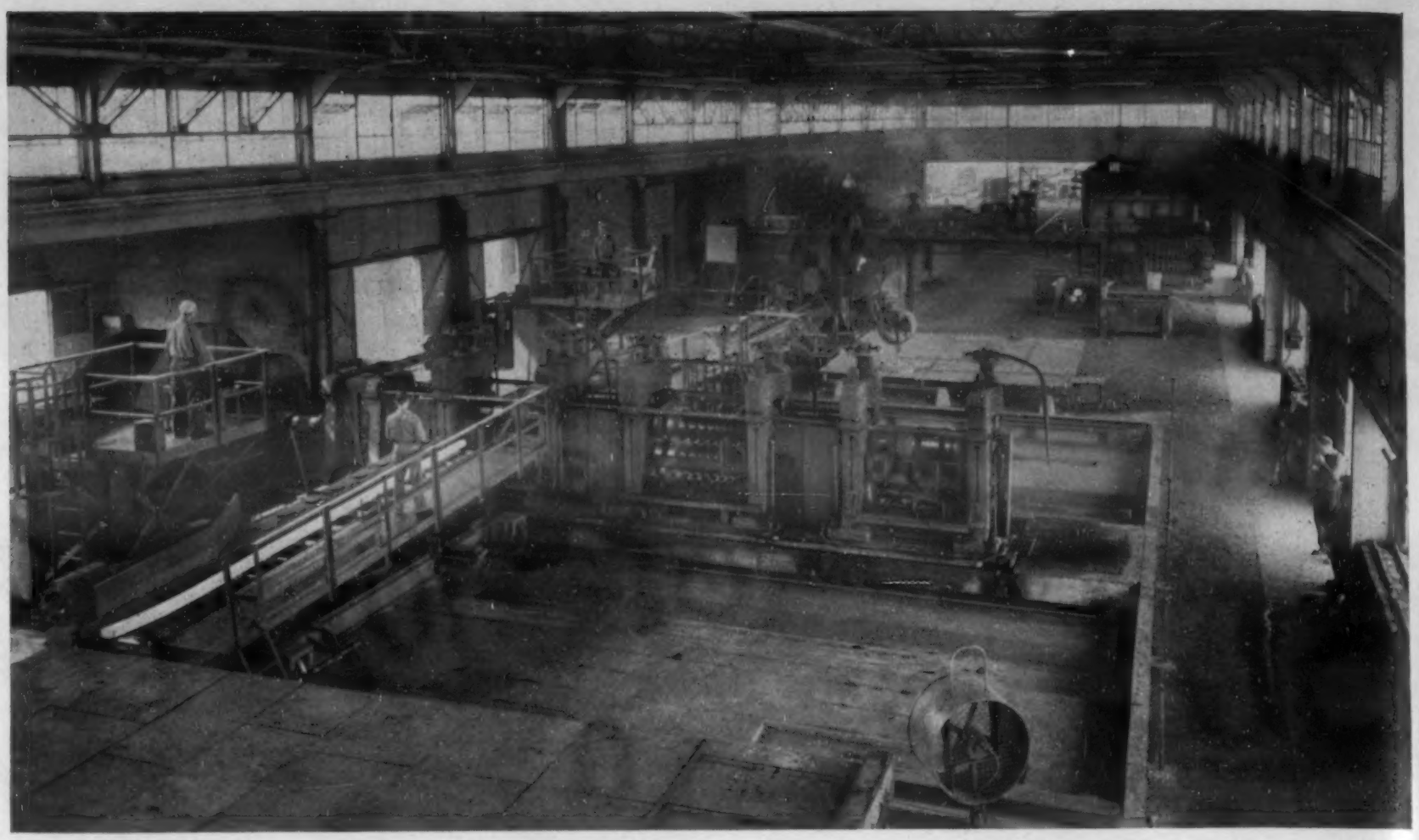
RUSTLESS IRON AND STEEL CORPORATION
BALTIMORE, MARYLAND

RUSTLESS
STAINLESS STEEL
BARS AND WIRE

PRODUCED BY AN ORGANIZATION
MAKING NOTHING BUT STAINLESS STEEL

SALES OFFICES: BALTIMORE · BUFFALO · CHICAGO · CINCINNATI · CLEVELAND · DETROIT · LOS ANGELES · PHILADELPHIA

DISTRIBUTORS WAREHOUSE STOCKS IN 18 CITIES



In this 20-in. mill the three stands reduce the metal to finished billet size. The moving tables quickly carry the stock from roll to roll and finally discharge it to the run-out table leading to the billet shear.

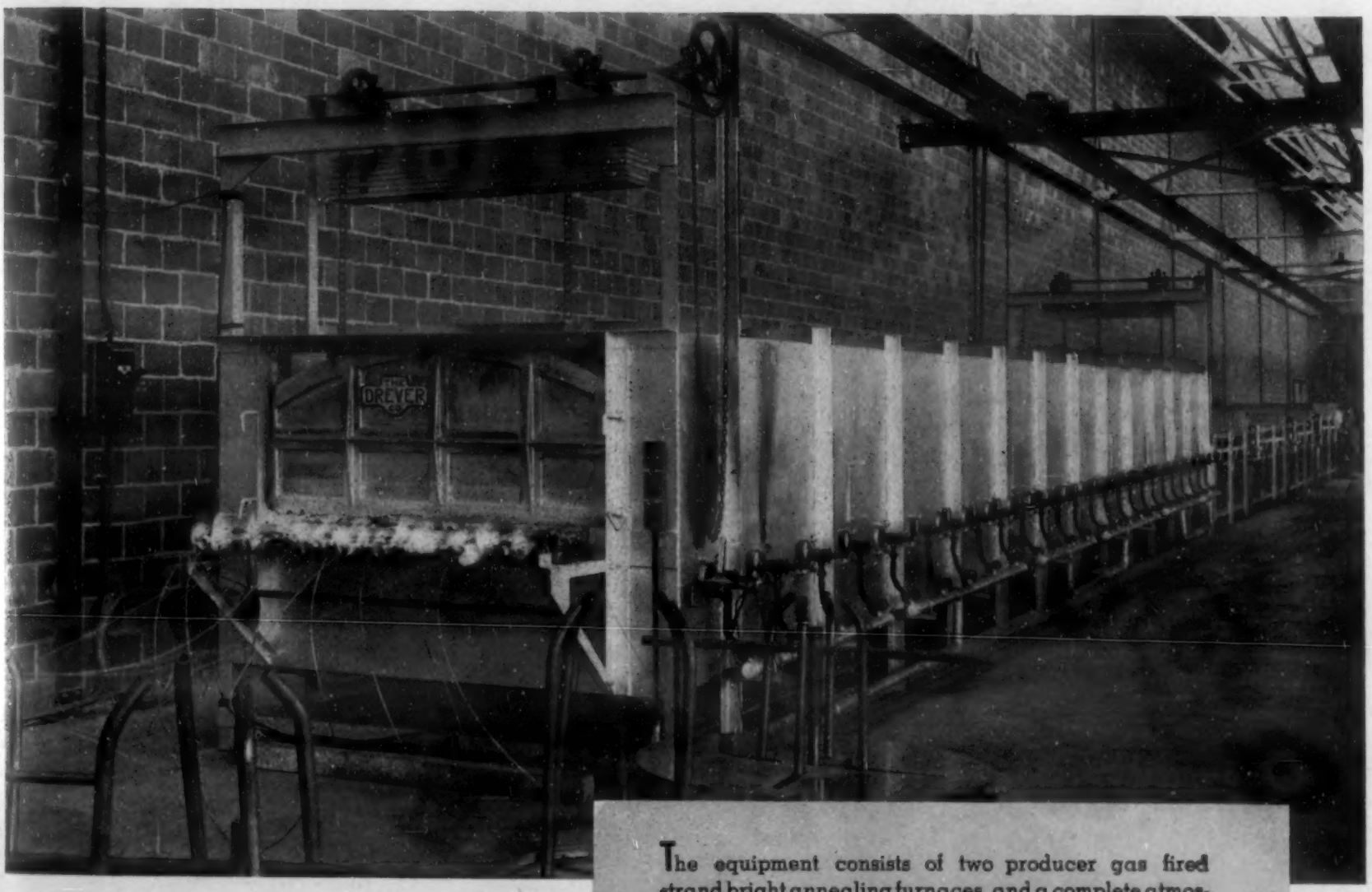
foreign and domestic, reduced and refined to the final products in electric arc furnaces. They saw also the methods of laboratory control for insuring standard quality carried out in a new laboratory; they were apprised of the many applications of stainless in the aviation, automotive, railroad and many other industries. They were also made more conscious of the growing trend toward a widely diversified number of applications where beauty, cleanliness and resistance to corrosion are of prime importance.

At noon at the plant the visitors were refreshed with a delectable buffet luncheon.

This double battery of grinders removes from all billets any surface imperfections and scale. The surface of each billet is ground 100 per cent.

RUSTLESS STAINLESS STEEL BARS AND WIRE

ONE of TWO 300 foot DREVER STRAND ANNEALERS for *Bright Annealing* STAINLESS WIRE



The Drever Company starts with your need . . . for furnaces to do a particular job well. Regardless of size, type, or production requirements, every furnace designed and constructed by Drever engineers is custom-made to meet the exacting conditions peculiar to your problems.

If you need to Surface Harden Stainless Steels, write for Bulletin on the Drever-Industrial Process

The equipment consists of two producer gas fired strand bright annealing furnaces, and a complete atmosphere gas generating unit for serving both furnaces.

The furnaces are designed to continuously bright anneal all analyses of stainless steel wire and each is equipped with thirty (30) alloy muffle tubes in which the wire is continuously heated in a pure dry gas atmosphere.

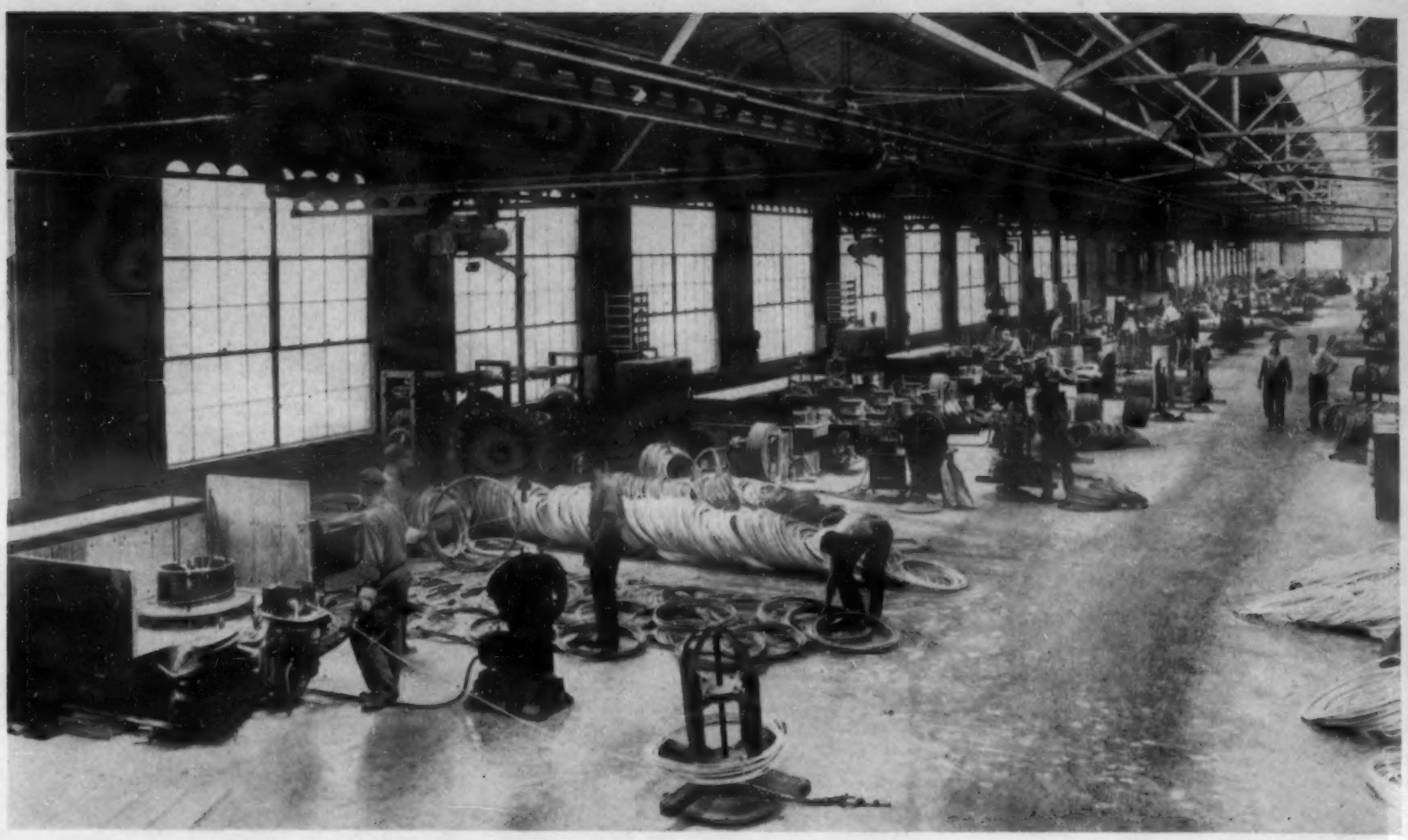
Both are anthracite producer gas fired by high pressure inspirator gas burners, zone controlled by potentiometer type control pyrometers.

Each furnace is lined with insulating refractory brick backed up by block insulation, graded according to temperature requirements.

Each unit, including reeling mechanism, etc., occupies an area of approximately 10' wide x 300' long. The gas generating and purifying system occupies an additional area of approximately 6' wide x 25' long.

THE DREVER CO.
760 E. VENANGO ST.
PHILADELPHIA, PA.

. . . Designers and Builders of Specialty Furnaces



Wire stock of the various grades of stainless steel is drawn through dies in the cold finishing department, insuring close control of size, improvement of physical properties and a mirror-like surface finish.

In the evening a dinner was tendered to many of them at the Belvedere Hotel where post-prandial speeches were made by Charles R. Hook, president of the American Rolling Mill Co.; James R. Young, International News Service correspondent; and J. H. Van Deventer, editor of *The Iron Age*.

Early Expansion: The first step in Rustless's expansion, authorized in 1935, was a $1,500,000 plant addition in 1937 increasing the ingot capacity from 20,000 to 40,000 tons a year. The current expansion, celebrated this year, has increased this capacity to 75,000 tons annually. In the

The cold-finishing department where hot-rolled annealed bars are cold drawn through dies to secure close dimension tolerances and to improve surface finish and physical properties.

Guaranteeing Quality
IN COILED WIRE ANNEALING
at RUSTLESS IRON AND STEEL CORPORATION

The Brown Potentiometer Controllers, pictured at right, are controlling temperatures at 2000°F. of four car-type annealing furnaces designed and built by Rustless engineers.

The illustration at left, shows Brown Potentiometer Proportioning Controllers controlling the temperature of mill ingot and mill billet furnaces.

Accurate temperature control of annealing operation is a fundamental requisite in maintaining the highest standard of quality at Rustless Iron and Steel Corporation, Baltimore, Md.—the country's largest exclusive producers of stainless iron and steel.

For indicating, recording and controlling temperatures in the treatment of metals, progressive manufacturers and metallurgists who demand more precise temperature measurement and dependable control of furnace operation are turning to Brown Potentiometer Pyrometers in increasing numbers and have proved to their own satisfaction, the dependability, accuracy and ruggedness of Brown Potentiometer Controllers for heat treating processes.

When you install Brown Potentiometer Pyrometers, you can rely on their precision—be confident of their dependability.

Why not learn more about Brown Potentiometer Pyrometers—how they can aid you in simplifying heat treating processes. Catalog No. 1104 describes in full detail, models and outstanding features of both electric and air-operated Brown Potentiometer Pyrometer Controllers. Write for a copy. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4517 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Toronto, Canada: 117 Peter Street—Amsterdam-C, Holland: Wijdesteeg 4—England: Wadsworth Road, rerivale, Middlesex—Stockholm, Sweden: Nybrokajen 7.

BROWN POTENTIOMETER CONTROLLERS
and
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

To Measure and Control is to Economize

past 2 yrs. the number of employees has increased from 450 to more than 1400. The program just completed represents the demolition of nearly all older buildings so as to make way for larger and more modern structures, which house much new and up-to-date equipment.

The Industry's Growth: Some idea of the growth of the stainless steel industry as a whole is afforded by interesting data made public by the company. These are based on statistics of the American Iron and Steel Institute which in 1934 began the publication of annual figures of the country's output. With the 1934 output equaling 100 per cent, the comparative production of stainless steel with all steel ingots shows:

Year	Stainless, Per Cents	All Steel Per Cents
1934	100	100
1935	132	131
1936	182	183
1937	280	194
1938	172	109
1939	321	181

The following table reveals the growth of Rustless's ingot output in comparison with the entire stainless steel industry:

Year	Stainless Per Cents	Rustless's Ingot Output, Per Cents
1934	100	100
1935	132	230
1936	182	367
1937	280	507
1938	172	229
1939	321	790
1940 (to July 1)	?	998

Melting and Rolling Capacity: Electric arc furnaces are used exclusively. In 1935 the melting facilities were changed from the original three 6-ton furnaces to three of 12-ton capacity. In 1940 two 16-ton furnaces were added making the capacity (75,000 tons) nearly 4 times that of 1935 and double that of 1937. The melting equipment at present is three 12-ton and two 16-ton arc furnaces.

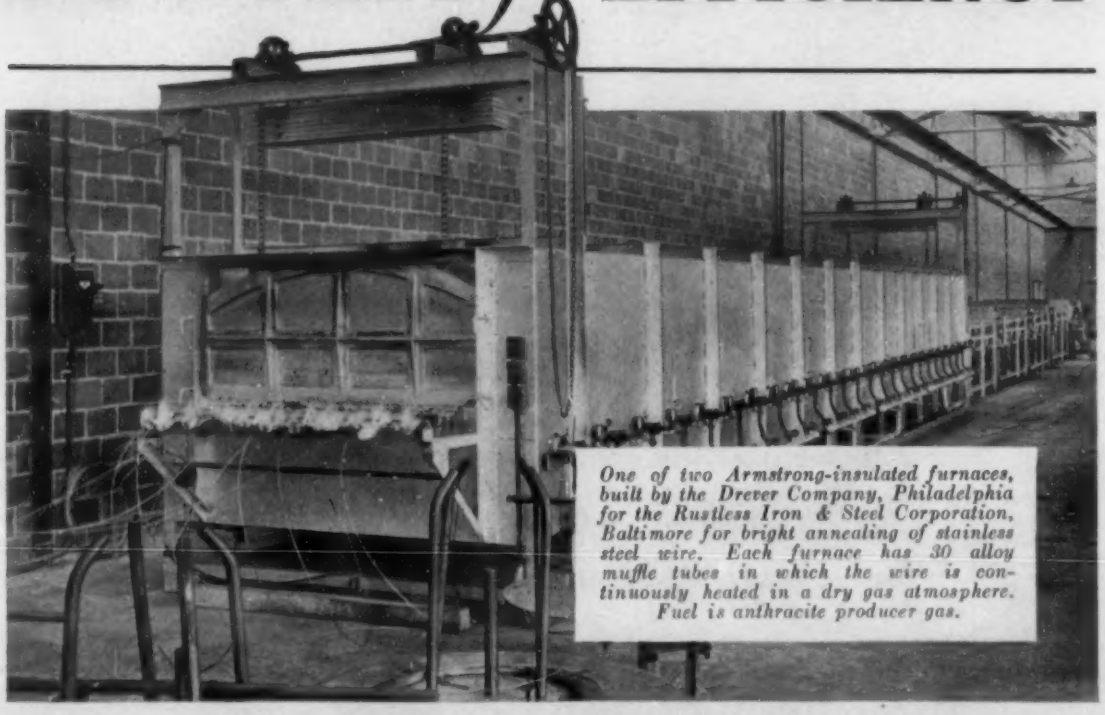
In 1935 the corporation's principal rolling mill equipment consisted of a 20-in. mill and a 5-stand 9-in. bar and rod mill. In 1937 a 12-in. bar mill was added. In 1940 a 28-in. mill has been added to produce billets, sheet bars and slabs as well as a 3-stand 12-in. mill and a 7-stand 9-in. mill for producing bars or coils. To the cold-finishing department there has been added equipment more than doubling the output, not including a new cold roll mill for making special bar and wire shapes to meet the requirements of special customers. Finished bar and wire capacity is now about 1500 tons a month or between 4 and 5 times the 1935 capacity.

The Products: The company is equipped to furnish stainless steels in semi-finished form—ingots, billets, slabs and sheet bars; and in finished products—bars, wire rods and wire. Practically every grade of stainless steel is produced.

It is the belief of the corporation's officials that it is the first one in the stainless steel industry to adopt the same straight line system of production which is used by automobile manufacturers. From

C. E. TUTTLE
President

300 FEET of OPERATING EFFICIENCY



One of two Armstrong-insulated furnaces, built by the Drever Company, Philadelphia for the Rustless Iron & Steel Corporation, Baltimore for bright annealing of stainless steel wire. Each furnace has 30 alloy muffle tubes in which the wire is continuously heated in a dry gas atmosphere. Fuel is anthracite producer gas.

ARMSTRONG'S BRICK KEEP FUEL COSTS DOWN—AID EXACT TEMPERATURE CONTROL— IN DREVER CONTINUOUS WIRE ANNEALING FURNACES

TWO new Drever gas fired annealing furnaces—each occupying, with reeling equipment, an area approximately 10′ wide by 300′ long—are serving efficiently in the Rustless Iron & Steel Corporation Plant, Baltimore, to continuously bright anneal all analyses of stainless steel wire. For close control of temperatures, and maximum fuel economy, Armstrong's EF-26 Insulating Fire Brick is used directly exposed in each furnace. Smaller quantities of Armstrong's N-20 and N-16 Brick were also used.

This installation is a typical example of the way Armstrong's Brick effectively serve the steel industry. Armstrong makes a complete high temperature line, including cements. Five individual brick are available—each adapted for a specific service at from 1600° to 2600°F. All Armstrong's Brick constantly meet high standards for crushing strength, thermal conductivity, tensile strength, spalling resistance, and other qualities—to assure satisfactory performance in almost any type of furnace.

Armstrong engineers will be glad to recommend the proper brick and cements for your installation. Write today for all the facts to the Armstrong Cork Company, Building Materials Division, 982 Concord Street, Lancaster, Pennsylvania.

Armstrong's
HIGH TEMPERATURE INSULATION
Color now aids the easy and accurate identification of the five types of Armstrong's Brick

ingot heating to the shipping department bars and wire are produced within a single 1800-ft. new building.

The visitors were first shown the melting department housed in a new building adjacent to which are stocks of chrome ore, scrap stainless and ordinary steel, and other raw materials. This building is not in the straight line production of the main plant, but it is conveniently adjacent to it.

The New Mill: Ingots, always cast big end up with a hot top, as is consistent with the best modern practice, are transferred to the end of the straight line production, 1800-ft., new rolling mill. The visitors were much impressed with this department.

Ingots are heated in large furnaces, fired with producer gas from the company's own producers. From these they pass to the 28-in. mill where they are broken down and then to the 20-in. mill which converts them into billets, sheet bars or slabs. In regular straight line production the various grades of stainless steel, mostly 18 and 8 and the straight chromes, pass to a grinding room where surface defects are removed; then to mills with suitable reheating furnaces, which roll them into wire rods.

There is a large department in line with the rod mills where pickling and other equipment is ample and where draw benches convert the rods into wire. One department of striking appearance contains a battery of two large wire annealing furnaces where mass production of 18 and 8 and other grades makes it possible to bright anneal in an inert atmosphere on a large scale.

At the end of the long building is the shipping department. In each department, where necessary there are found annealing and heating furnaces, straightening machines and other equipment.

In one of the older buildings there is a 7-stand, 12-in. mill where large rounds, flats, hexagons, or special sections are produced. And in another older building, there is a cold-finishing department where annealed bars are drawn through dies to secure close dimensional tolerances and to improve surface finish and physical properties. Here various centerless grinders and straightening machines perfect the products.

A feature of the entire plant is a new chemical and metallurgical laboratory, fully equipped with all modern necessary apparatus. It is located close to the new melting department.

Officers of the Rustless Iron and Steel Corp. are: C. E. Tuttle, president and chairman of the board; T. F. McLaughlin, vice president; M. K. Schnurr, secretary and treasurer; and N. J. Cadin, controller. E. P. Geary is assistant vice president in charge of sales; W. B. Pierce is sales manager, and S. P. Watkins is manager of sales development.

Part of a storage yard of ingots and billets; all identified as to analysis and heat.

For Efficient Pickling
RUSTLESS Chooses RODINE

The Rustless Iron and Steel Corporation of Baltimore, Md., has made great strides in developing and producing alloy steels. Their new mill gives ample evidence of this leadership. The pickling room (shown above), for instance, is a model for efficient cleaning and descaling.

For many years the Rustless Iron and Steel Corporation has used Rodine, and they will continue to use Rodine in the modern pickling room of their new mill. For Rodine has effected substantial savings in acid and metal, and enabled Rustless to produce a bright, smooth product.

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT CO.
General Offices and Factory
AMBLER, PA.

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

INSPECTION AND CONTROL

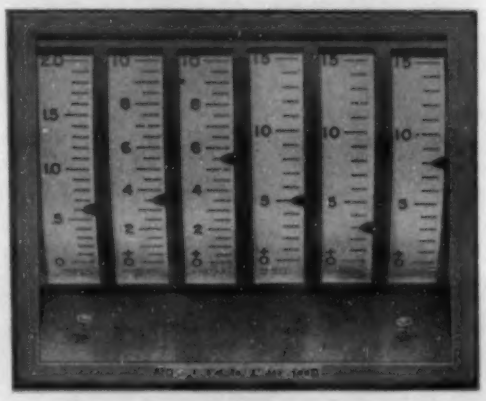
The normally vital importance of accurate instruments, gages and inspection equipment in the metallurgical engineering industries has been sharply increased and intensified in the accelerating national defense program. Army, Navy and Air Corps specifications are characterized by narrow tolerances, and contractors and sub-contractors alike are learning the value of careful process and product control. Then, too, the familiar term "aircraft quality" takes on new force when its applications are multiplied several-fold, as at present.

Control Instruments

Process control depends to a large extent on instruments that indicate, record or automatically control temperatures, pressures, speeds, etc. in melting, rolling, annealing, heat treating, forging, welding, finishing, etc. For indicating, recording or controlling process variables far-removed from the point of measurement, *Taylor Instrument Companies*, Rochester, N. Y., has developed the Taylor remote pneumatic transmission system, said to be particularly advantageous where it is desirable to correlate temperature, pressure, flow or liquid level data on a centralized panel or in a control room. The system features simplicity, accuracy and economy.

Pneumatic systems of this type eliminate the hazards of electrical transmission by doing away with electrical circuits in explosive atmospheres, it is said. In this case standard Taylor instruments are used, with one or more transmitters or one or more receiving instruments, as far as 1000 ft. from the transmitter. The transmitting medium, air pressure, is carried by ¼ in O.D. copper tubing.

Brown Instrument Co., Philadelphia, is offering a new and improved "Radiamatic" pyrometer designed to operate under severe conditions of temperature, vibration, atmosphere, etc. The pyrometer is of the radiation type, in which the heat from the hot object is focused on a current-generating thermopile.



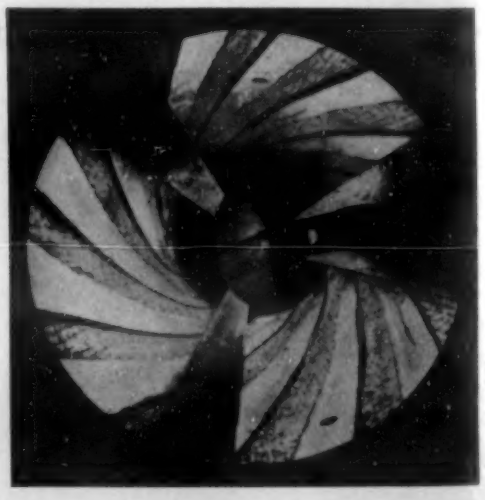
For indicating drafts, pressures and other factors in industrial furnaces and boilers, a new multi-point indicator is being marketed by *Republic Flow Meters Co.*, 2240 Diversey Parkway, Chicago. Each unit can be withdrawn without disturbing the others. The indicator (illustrated) is supplied with from 2 to 16 of these interchangeable units, with scales illuminated from the rear.

Boiler corrosion control is now available through a dissolved-oxygen recorder sensitive to 1 part of oxygen in 400,000,000 parts of feedwater. The instrument, developed by *Cambridge Instrument Co., Inc.*, Grand Central Terminal, New York, is completely automatic and provides a continuous indication and record of dissolved oxygen entering the boiler, replacing tedious and necessarily discontinuous chemical methods. The instrument records full-scale on a chart 10 in. wide.

Gages and Surface Inspection

Of great importance in connection with the defense program, since it not only is suitable for the visual examination of bores, tubes and other recesses but is particularly useful for the inspection of gun barrels, is a new bore inspection telescope (M 2125) offered by *Gaertner Scientific Instruments Corp.*, 1201 Wrightwood Ave., Chicago. Small holes, cracks, pits, scratches and other defects are readily seen since the instrument provides a clear and detailed view, much enlarged, of the inner walls of bores being examined.

Inspection can be made in tubes 1 in. to 4 in. in diameter, and, with the aid of available extensions, to a depth of 20½ ft. An illuminating head supplied with the instrument carries a special tubular lamp, the clear portion of which is 6 in. long. An adjustable inclined mirror permits inspection at right angles to the wall as well as along the inner walls of the bore. The price of the equipment supplied with spare lamps, cord, 6 v. transformer and a case is $300.



Largely as the result of national defense and foreign war orders, the whole gage industry this year has shown business gains from 100 to 600 per cent over last year. According to *Carboloy Co., Inc.*, E. Eight Mile Rd., Detroit, there is a tendency among purchasers to specify longer life gages such as the chromium-plated and the cemented-carbide types, which provide long-term economies despite their higher cost and relieve the strain on gage production capacity.

A new line of machinists' tools is announced by *George Scherr Co., Inc.*, 128 Lafayette St., New York, fully guaranteed for accuracy and precision workmanship. The line comprises combination sets of several types including dividers, inside and outside spring calipers, hardened and tempered center gages, thickness, depth and surface gages, magnifiers, etc.

The use of Dynetric balancing machines has increased the bearing life and given smoother operation of precision machines and engines, reports *Gisholt Machine Co.*, Madison, Wis. A specific case in point is

the employment of a Gisholt type 1 S Dynetric balancing machine in conjunction with a calibrated drill for removing metal from the large end of the spindle whorl and with a calibrated internal keyway cutter mounted on a drill for removing metal from the tube end—all in a rayon spinning machine.

Two new accessories for use with the Profilometer (an instrument for measuring the roughness of precision-finished metal surfaces) and a new Profilometer model for unusually sensitive work are announced by *Physicists Research Co.,* Ann Arbor, Mich. The first is the Mototrace, an instrument for mechanical operation of the tracer when the latter is on awkward or inaccessible surfaces. The other accessory is a special tracer for measuring the roughness inside small holes, etc. The new special Profilometer has a 1-microinch scale for especially fine work, such as gages.

Internal Flaw Detection

The latest Sperry rail-flaw detecting equipment permits the detection of hazardous, internal rail defects, such as transverse fissures and progressive fractures, even when under or adjacent to engine driver "burns," announces *Sperry Rail Service,* Hoboken, N. J.

Development of a new cold-cathode ultra high-speed X-ray tube that makes millionth-of-a-second radiographic exposures was recently described to members of the American Physical Soc. by C. M. Slack of *Westinghouse Lamp Division's* research laboratories, Bloomfield, N. J. The new tube is believed to make possible X-ray motion pictures, the study of internal strains in rapidly-moving mechanical parts, and the rapid radiography of metals generally.

E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., have just developed a "fast" X-ray film that is said to save 30 to 40 per cent on exposure time as compared with films heretofore available. Using this film, lower voltages can be employed for heavier plates. No sacrifice in uniformity is involved in the use of this new film, which is said to be resistant to moisture, high temperatures, etc.

● For those interested, *Bausch & Lomb Optical Co.,* Rochester, N. Y., has issued a factual discussion in booklet form of Bausch & Lomb's relation to national defense, which refutes attacks on the company's loyalty and patriotism engendered by an indictment that charged restraint of trade in military optical instruments. Readers will recall that the case was settled out of court in July.

● A new polishing grain made of fused aluminum oxide produced in the electric furnace and said to be unusually uniform has been christened "Vanite" by its suppliers, *Hanson-Van Winkle-Munning Co.,* Matawan, N. J.

● Working in cooperation with the University of Michigan's Dept. of Physics, the spectrochemical laboratory at the *Ford Motor Company's* Rouge plant has developed a spectroscopic technique that permits the analysis of a metal sample to be completed within 6 min. after receipt, with a probable error no greater than 1 per cent of the content for each element.

Turning this steel casting for a General Electric rotor spider hub with two single-point Carboloy-tipped tools removes chips at a rate of 612 lbs. per hr., reports Carboloy Co., Inc.

Controlled Luminous Flame for Reheating Furnaces

To provide the basic advantages of luminous flame firing in reheating billet furnaces and soaking pits without the drawbacks of incomplete combustion and poor control inherent in present systems, *Morgan Construction Co.,* Worcester, Mass., announces the "Controlled Luminous Flame."

This new development in luminous flame firing makes possible the regulation at will of the length of the flame and effects complete combustion at the end of the flame. The Morgan luminous flame burner employs the well-known principle of flame stratification, and also provides for adding a control mixture with the fuel gas admitted to the furnace.

The composition of the control gas may be 100 per cent air, 100 per cent waste gas from the flue or any needed proportion of air and waste gas—the more air in the control mixture the shorter the flame. Adjustments can be so made that the ends of the billets will be heated entirely satisfactorily by compensating the end burners for the loss of heat from the outside wall.

The Morgan burner is applicable without great change to all billet heating furnaces. The luminous type of flame assures a practically constant temperature over the entire hearth. Control is said to be simple and may be made automatic if desired.

Tin-less Bronze in Defense Work

As a result of the shortage of tin in the last war and the desirability of having a lighter and stronger bronze casting alloy, a new type of bronze—P-M-G metal, containing silicon and iron—was developed. According to *Phelps Dodge Copper Corp.,* 40 Wall St., New York, the alloy has demonstrated its special value in naval construction and should play an important part in the naval rearmament program now under way in this country.

The alloy is of lower specific gravity than conventional tin bronzes, has greater strength, fatigue-resistance and impact value, and is particularly resistant to sea-water corrosion, it is claimed. Not only in the naval service, but in the army ordnance departments, P-M-G metal is said to be in use for fire control instruments, sighting equipment, brackets, fittings, torpedo tubes, shell-hoists on big guns, bushings, bearings, rods, bolts, gears, housings and shaftings.

The alloy was developed by Goudielock in England during the years prior to 1926, and its manufacture in the United States and Canada is controlled by Phelps Dodge.

● A new ceramic pot supplied with Holden electric pot furnaces for scale-free forging or hardening of high-speed steels will provide at least 2,000 hrs. life at temperatures between 1850 and 2300 deg. F., says *A. F. Holden Co.,* New Haven.

Free-Cutting Carburizing Steel

Comprehensive data on the mechanical properties, machinability, heat treating and carburizing behavior, finishing and forming of "Speed Case"—a low-carbon, open hearth, free-machining, case carburizing steel—has been issued by *W. J. Holliday & Co.*, Hammond, Ind.

Speed Case is said to possess mechanical properties better in many cases than ordinary open hearth steels, plus all the cutting characteristics of a free-machining steel. A typical analysis is 0.20 per cent carbon, 1.25 manganese, 0.250 sulphur, 0.03 maximum phosphorus and 0.02 maximum silicon. This is thus a carbon-manganese steel; the free-machining quality is due to the high sulphur content, and the good mechanical properties are attributed to the high manganese.

Hot-rolled Speed Case plate has a tensile strength of 62,000 to 72,000 lbs. per sq. in.; elongation of 30-35 per cent in 2 in.; Brinell hardness of 141-156. It is said to have higher impact resistance at sub-zero temperature than ordinary S.A.E. 1020, and will take a cold bend of 180 deg. without splitting or fracture.

Fine or coarse cuts can be made without tearing or chattering, and machining is often done without cutting oils, it is claimed. At cutting speeds of 150-250 surface feet per min. tool life averages 5-15 times that of other open hearth steels, reports the manufacturer.

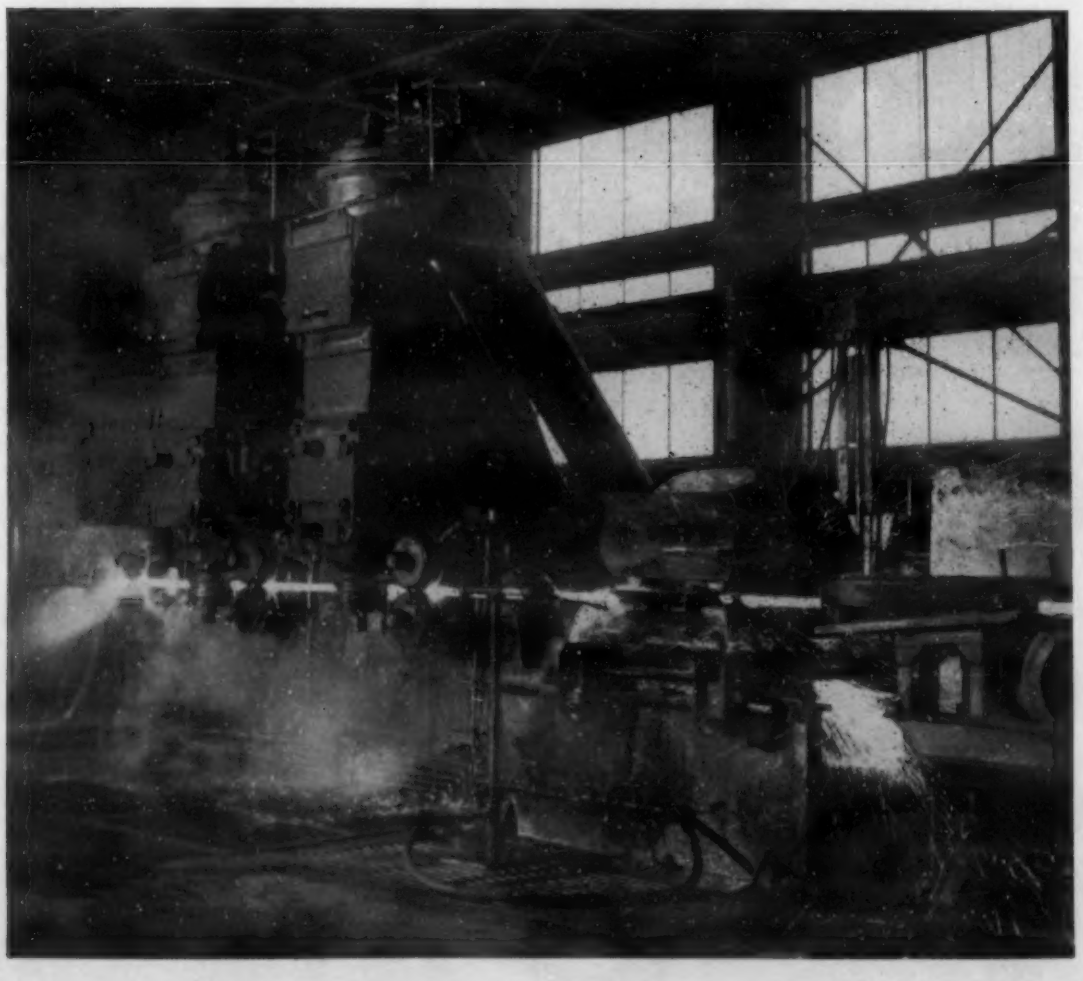
Speed Case responds remarkably to carburizing, it is said, carburizing time being reduced 5-25 per cent as compared with steels for similar applications. Penetration is deep, with a uniform case hardness of 62 to 66 Rockwell C plus a tough core.

● The widespread application of porcelain-enamelled iron has been extended to roofing and siding by the development of an interlocking corrugated sheet porcelain-enamelled on both sides. Known as Por-Ce-Lok, the new product is fabricated on a specially designed 12-stand, cold-roll-forming machine 55 ft. by 8 ft., with a production speed of approximately 120 ft. per min. in the ordinary gages, reports *American Rolling Mill Co.*, Middletown, Ohio.

● A new inorganic finish, called Pyroflex, just introduced by *Porcelain Enamel & Mfg. Co.*, Baltimore, is said to reduce the burning temperatures of porcelain enamel about 200 deg. F. and to permit the use of lighter-gage stock. It is described as inexpensive yet resistant and versatile.

● A new series of rust preventives announced by *E. F. Houghton & Co.*, Third & Somerset Sts., Philadelphia, includes liquid rust inhibiting non-drying products, non-drying grease-type materials, drying hard-film products, semi-drying waxy-film coatings and soluble rust preventives.

New Continuous Butt-Welding Mill



The Maryland plant of *Bethlehem Steel Co.* is now operating a new continuous butt-welding mill for pipe, in which electric flash welders join successive coils of skelp to form a continuous strip.

The skelp, after leaving the heating furnace, is drawn through a series of 6 roll passes. A flying hot saw then cuts the welded pipe into desired lengths. The mill, equipped with 2 continuous units, produces butt-welded pipe in all standard sizes from ⅜ in. to 4 in. diameters.

New Straight Tungsten Carbide

A straight tungsten carbide grade of Kennametal said to be 15 per cent stronger than other tungsten carbides of the same hardness has been placed on the market by *McKenna Metals Co.*, 158 Lloyd Ave., Latrobe. Pa.

Known as "Kennametal grade K4," this new carbide tool material has a hardness of 92 Rockwell A and strength of 223,000 lbs. per sq. in. (transverse rupture test), as compared to a hardness of 91.8 Rockwell A and a strength of 190,000 lbs. per sq. in. for a comparable competitive brand of tungsten carbide.

The new grade of Kennametal is particularly applicable to the machining of hard, crumbly materials such as cast iron, "transite" pump, Bakelite, porcelain, hard rubber, glass, casein—as well as silicon-aluminum. hard bronze and other non-ferrous materials, and thus supplements the older steel-cutting grades of Kennametal.

Shape-Die Finishing Equipment

The use of drawing dies for short runs on special shapes is now economically feasible through recent developments of *Carboloy Co., Inc.*, East Eight Mile Rd., Detroit.

A complete line of equipment for finishing and servicing Carboloy (cemented carbide) drawing dies for producing special shapes of bar and rod is being made available by this company directly to users, enabling them to employ such dies economically for all lengths of runs and several types of shapes. At the same time, Carboloy is offering shaped dies in low-priced cored or pre-formed states for rapid finishing to final shape through the use of the new equipment.

These dies are so designed as to require a minimum of stock removal for finishing to the usual sizes. Essentially, the finishing equipment consists of a die-bearing sizing machine, a die-shape machine, a hand polishing tool and an adaptation of a bench shaper for machining the required laps.

New Aircraft Welding Electrode

A new arc welding electrode of special utility in the fabrication of aircraft engine mounts and landing gear forks has been developed by *Lincoln Electric Co.*, Cleveland. Known as "Planeweld," the electrode is of the shielded-arc type and is particularly suitable for welding chromium-molybdenum (S.A.E. 4130 and X-4130) steels, in all positions.

The new electrode is available in 2 types—Planeweld No. 1 for material 0.120 in. and heavier, and Planeweld No. 2 for light-gage airplane parts and airplane tubing. The No. 1 grade can be had in ⅛ in. and 5/32 in., and No. 2 in 1/16 in. and 3/32 in. sizes.

Planeweld electrodes are suitable for welding fuselages, torque tubes, bomb mountings, alloy chain links, antenna mounts, chairs, engine mounts, landing gear forks and other airplane parts made of the steels mentioned.

New Combustion Safe-Guard

The recently developed Protectoglo, photoelectrode system, of *Brown Instrument Co.*, 4431 Wayne Ave., Philadelphia, is said to provide a safe and reliable method of protection against failure of oil, powdered coal and luminous gas flames. The photoelectric principle employed avoids the need for placing a metal electrode in the flame, yet retains the quick response characteristic of thermionic systems.

The function and operation of the photoelectrode are similar to the familiar Brown flame-electrode Protectoglo system. The principal difference is in the method of flame protection; instead of using a metal electrode, the photoelectrode system detects the presence of a flame by means of the light emitted when a burner is in normal operation.

In operation the light from the flame is directed on a photocell which operates a relay to energize the main fuel valve. The system is said to be fool-proof, yet through its design, to avoid unnecessary shut-downs because of transient flame disturbances.

News of Metallurgical Engineers

Paul D. Merica, vice president, International Nickel Co., New York, has been elected a vice president of the American Institute of Mining and Metallurgical Engineers. . . . *Clyde E. Williams,* director of Battelle Memorial Institute, Columbus, has been named a director of the A. I. M. E. . . . The Samuel Wylie Miller Memorial Medal of the American Welding Society was awarded to *Wm. Spraragen,* technical secretary of the Society and editor of *The Welding Journal,* at the Cleveland meeting. . . .

W. M. Black, formerly vice president of American Manganese Steel Div., American Brake Shoe & Foundry Co., is now president of the division. . . . *L. M. Nesselbush* was recently elevated from sales engineer to vice president and a director of Falcon Bronze Co., Youngstown, Ohio. . . .

Wellman Engineering Co., Cleveland, Ohio, announces the placement of *L. R. Kells* in charge of its furnace department. . . . *Jackson H. Beyer* has joined the staff of the Non-Ferrous Metallurgy Div. of Battelle Memorial Institute, Columbus, Ohio. . . . *R. A. Karr* has been appointed metallurgist at Copperweld Steel Company's new Warren, Ohio, plant.

Shaped Wire

The purchase of "shaped" wire rather than the forming of finished shapes by hand or machine is a practice of growing appeal to engineers and designers in a host of industries. According to *Page Steel & Wire Div.* of *American Chain & Cable Co., Inc.*, Monessen, Pa., big savings of time and money can be had, since production forming operations are thus eliminated.

Page shaped wire is available in squares, triangles, keystones, half-rounds, rounds, full ovals, flats, and special shapes. Size ranges include cross-sectional areas up to No. 3 B.W.G.—about ¼ in. square; flats and rectangles can be had in widths up to ⅜ in. with the width-to-thickness ratio no greater than 6 to 1. The shapes are available in low-carbon steels, high-carbon steels, stainless steels and Armco ingot iron.

The savings in buying wire shapes already cold-rolled or cold-drawn to the finished size desired are most noticeable when certain "standard shapes" are ordered, but are also evident with special shapes even though for the latter a tool charge, which will vary with the nature of the shape, must be applied.

Mammoth Stress-Relief Furnaces for New Battleships

The Brooklyn Navy Yard has recently installed what is believed to be the largest convection-type furnace in existence. It is used for stress-relieving welded gun turrets and other structures for new giant battleships like the *Iowa* and *Missouri.*

The furnace—designed, fabricated and installed by *Surface Combustion Corp.*, Toledo, Ohio—is 56 ft. long, 48 ft. wide and 30 ft. high inside. Its gross-charge rating is 672,000 lbs., with maximum gas input 16,000,000 B.t.u.'s per hr. The estimated time to heat a rated charge to 1250 deg. F. is 36 hrs. A duplicate furnace is installed in the Philadelphia Navy Yard.

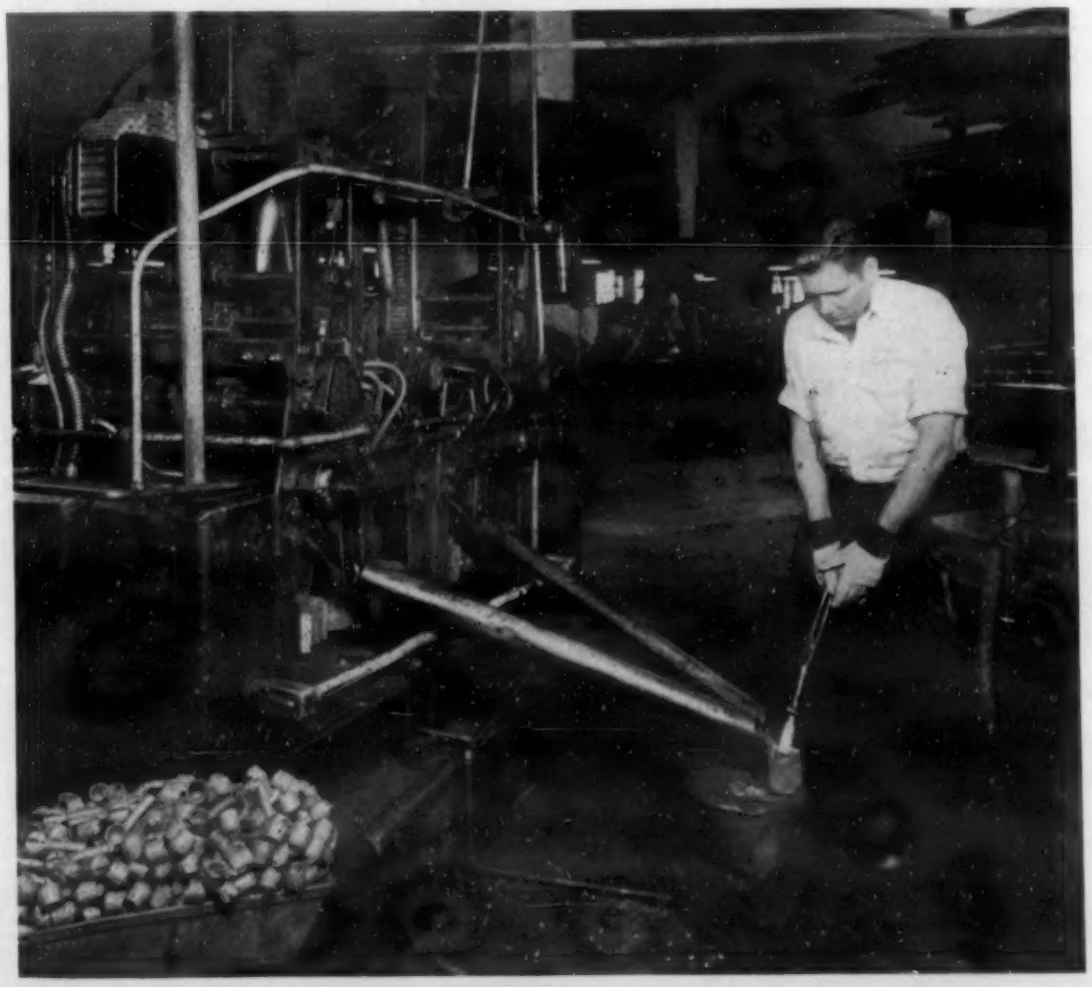
Electronic Welding Timer

The recently announced "resistance forge-welding" process (see our October issue, page 484) for spot welding heavy steel sections involves a complicated sequence of accurately-timed operations. This timing control is made possible through a specially designed "Weltronic" welding timer of the electronic type designed and built by *Weltronic Corp.*, 2832 E. Grand Blvd., Detroit.

This timer, it is said, provides accurate timing control for current-passing, welding pressure, impact forging pressure, cooling time, holding time, etc. In addition, the timer can time any combination of functions required in spot welding heavy sections by resistance forge-welding and can be used with either standard or special equipment. The automatic operation of the Model 79 timer eliminates the need for operator-skill, even though fabrication of heavy sections is required at speeds approaching those for spot welding sheet metal.

All operating elements of the Weltronic timer—electronic tubes, relays, etc.—are mounted on a panel and enclosed in a cabinet to permit mounting on either the welding machine or a separate stand conveniently located.

Resistance Heating for Automotive Forgings



At Thompson Products, Inc., Detroit, socket ends for automobile steering systems are upset-forged from ¾ in. diam. steel rod. The stock is heated for upsetting in these Berwick electric metal heaters, manufactured by the *American Car and Foundry Co.*, New York.

These heaters, equipped with hopper feed mechanism and photoelectric temperature control, locally heat the ends of the stock by passing current directly through each piece, thus providing quick heating with minimum scaling and freedom from burning, it is said. Heating at a rate of 8-pieces per min., the total demand on both heaters illustrated is 35 kw.

Punch Fixtures and Dies

Elimination of large and costly dies and large press equipment with cam mechanisms for punching mounting holes in various sheet metal parts for a 1941 model automobile has been accomplished through the development of special fixtures made up of small individual punching units and die

sections, according to *Progressive Welder Co.*, 3081 East Outer Drive, Detroit. The fixtures are so arranged that any change in design of the part itself or its mounting simply involves re-arrangement of the punching units and dies. The radiator shell as well as both front fenders are now handled on such equipment.

The fixtures used consist of individual hydraulic punching units, each having one or more punches and mounted on die brackets which are in turn mounted on the base plate of the fixture. Instead of a large single-piece unit, the punching die is made in sections. These are also mounted on brackets so that each die and unit form a complete punching set-up in itself.

In operation, it is only necessary for the operator to place the work on the dies and press both safety switches, the locating, punching and stripping being completely automatic.

● To rotate a disc on a shaft located inside a vacuum-sealed chamber without making any mechanical connection thereto, *General Electric* research engineers employ 2 Alnico magnets as "gears", one attached to the mechanism inside the furnace, and the other independently supported outside. When the outside magnet is rotated, the inside magnet also revolves and turns the mechanism, which is used to coat aluminum disks for photocells with vaporized selenium.

Surface Hardening by Induction

Small-parts manufacturers will be interested in the possibilities for low-cost surface hardening offered by the new Tocco, Jr. type MG 10, of *Ohio Crankshaft Co.*, 6600 Clement Ave., Cleveland. The new units are available in 5 sizes, from 10 to 80 kw. output, and are completely self-contained. They are built with 1 to 3 hardening stations and can be adapted to brazing, soldering and heating for forming by simply disconnecting the quench water.

The new units follow the design of the larger Tocco machines. The advantages claimed for this method of hardening are that each part can be selectively hardened at the wearing surface only, and that parts are treated free of scale, decarburization and distortion.

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit, Mich., Jan. 6-10.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual meeting. New York, N. Y., Jan. 15-18.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, annual meeting. Kansas City, Mo., Jan. 27-29.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter meeting. Philadelphia, Pa., Jan. 27-29.

INSTITUTE OF AERONAUTICAL SCIENCES, annual meeting. New York, N. Y., Jan. 29-31.

New Wear-Resistant Non-Magnetic Steel

A new austenitic non-magnetic steel containing 11-13½ per cent manganese and 3½ nickel, said to be especially useful for abrasion resisting applications, is now carried in stock by *Joseph T. Ryerson & Son, Inc.*, 16th & Rockwell Sts., Chicago, Ill.

Considerable industrial importance is attached to the availability of this non-magnetic, abrasion resistant and weldable steel, called Manganal. For example, considerable weight can be saved in building composite structures by welding castings and Manganal plates, using Manganal only where necessary for wear-resistance. Because the steel is austenitic, it can be cooled from welding temperature without loss of toughness. Welding rod of 18/8 stainless steel is said to be very satisfactory for welding Manganal.

The new steel is claimed to have all the advantages of 11-14 per cent manganese steel and, in addition, to require no subsequent heat treatment when formed or punched hot. Tensile strengths up to 150,000 lbs. per sq. in., elastic limit 55,000-60,000 lbs. per sq. in., 72½ per cent elongation in 2 in. and 54 per cent reduction of area are some of the physical properties claimed for this steel.

Hot rolled Manganal plates are reported to be in use for electrical applications, for patching broken parts and as a substitute for heavy castings.

Cleaner for Aluminum and Tin

A special alkaline silicate cleaner for aluminum and tin, and alloys of either, has been announced by the *Philadelphia Quartz Co.*, Philadelphia, as the latest addition to their line of "Metso" cleaners.

The ingredients of the new cleaner, called "Metso 88 Special," permit effective use in either hot or cold, hard or softened water. The cleaner is a free rinser. It goes into solution immediately and is completely soluble, thus eliminating the danger of the cleaning material settling to the bottom of the tank.

The cleaner quickly removes animal, vegetable or mineral oils, as well as solid dirt, from sensitive metal surfaces and at the same time provides a greater margin of safety than is available from the alkaline cleaners ordinarily used. It is packed in concentrated liquid form and merely requires dilution before use.

Magnetic Separator for Powders

An unusual type of magnetic separator which utilizes alternating current for energizing the magnetic field has been designed by *Stearns-Magnetic Mfg. Co.*, 635 So. 28th St., Milwaukee, and designated Type AM. This new separator is particularly useful for treating finely-ground powdered metal that may be contaminated by various kinds of impurities.

The material is spread uniformly by an adjustable vibrating feeder on to the separator belt where it is picked up by the magnet and carried along the underside of the separating belt. The high pulsating effect of the magnet frees the non-magnetic impurities alloying them to drop out. Under ordinary conditions tails, middlings and concentrates can be produced.

● Tungsten wire for incandescent lamps is machine-wound into coils which often have more than 2100 turns per inch. According to *Westinghouse Elec. & Mfg. Co.*, E. Pittsburgh, the coils themselves are now being wound like solid wire into further coils to produce the most efficient incandescent element yet devised—the coiled-coil filament.

Free Service Department

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HELP WANTED: General Alloys Co. is expanding, and anticipates need of men experienced in all phases of cast heat and corrosion resistant alloy business. Will consider men experienced in furnace engineering or kindred lines. Shop, office, sales and engineering. Write fully stating education, experience in detail, personal details and starting salary expected. Your application will be held in strict confidence. Box MA-32.

HELP WANTED: Young graduate metallurgist with practical knowledge of the processing of stainless steels. Should be competent in metallography and experienced in the investigation of metallurgical problems of stainless steels in production and in the field. Give training and experience. Box MA-33.

POSITION WANTED: Chemist, experienced in the analysis of ferrous and non-ferrous metals and alloys. Has worked on tests for resistance to corrosion. Able to translate from and to German. University graduate. Box MA-35.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

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1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

1a. Ferrous

Cerium Additions to Cast Iron

THE EFFECT OF CERIUM ADDITIONS ON CAST IRON ("Ueber den Einfluss von Cermischmetall auf Gusseisen") W. BAUKLOH & H. MEIERLING. *Giesserei*, Vol. 27, Sept. 6, 1940, pp. 337-341. Research.

Existing literature shows that cerium favors the formation of white iron, and aids in the removal of impurities, particularly oxygen, nitrogen and sulphur. Experiments are described in which a cerium alloy of 51% Ce, 46.9 other rare earths, 0.13 Si, 0.55 Fe, 0.62 Mg, 0.03 Al, and 0.02 Ca was melted and added to a ladle containing 120 lbs. of liquid cast iron.

The cerium content of the finished metal was always much lower than the amount of cerium added. Some of the lost cerium goes into the slag, and some of it burns off. The sulphur content is considerably reduced and the tensile strength noticeably increased by cerium additions in which the cerium content of the finished casting varied between 0 and 1.5% (2% addition), depending on the amount and manner of cerium alloy addition. Brinell hardness increased from 209 (no cerium) to 237 (2% addition).

A very remarkable effect seems to be exerted on the fluidity; when tested by the Sipp method (casting a spiral of given dimensions) the maximum fluidity was obtained with a cerium addition of 0.50%; this remained about the same to 0.75% and then dropped again up to 2% Ce addition. The increase in mechanical strength is ascribed to the fact that cerium is a carbide former and thus hinders graphitization. On the other hand, part of the CeC_2 formed burns away in pouring, forming fine cerium oxide particles; these are finely distributed in the melt and can be considered as nuclei for graphite formation. Furthermore, CeC_2 disintegrates in cooling to $CeC_2 + C +$ heat, and the carbon thus formed also acts as to initiate graphitization.

Desulphurization is connected to a certain extent with the increase in liquidity, due apparently to the exothermic reactions that occur after addition of the cerium alloy; a 55° F. increase in the temperature of the iron could be observed. Since the melting point of the iron was reduced by only 8° F. by the addition used in these tests, the greater fluidity cannot be attributed to melting point lowering.

This greater fluidity can be utilized to advantage for special cast irons, and for thin-walled castings, for the mechanical strength is simultaneously improved. The increase in tensile strength was approximately linear from 27,000 lbs./in.^{2} at 0% Ce to 57,000 lbs./in^2 for 2% Ce addition. The sulphur content was reduced from 0.12% to about 0.02 in the same cerium addition range. Ha (1a)

Graphitization in Steels

"EFFECT OF COMPOSITION AND STEELMAKING PRACTICE ON GRAPHITIZATION BELOW THE A_1 OF EIGHTEEN ONE PER CENT PLAIN CARBON STEELS." CHARLES R. AUSTIN & MAURICE C. FETZER (Penn. State Coll.) *Metals Tech.*, Vol. 7, Sept. 1940, 12 pp. Investigation.

The tendency for these 18 steels to graphitize when held for long times below A_1 was determined. The steels were all made in the electric furnace—some in an arc furnace and some in an induction furnace. All were analyzed for carbon, manganese, phosphorus, sulphur, silicon, nickel, chromium, copper, nitrogen, aluminum, alumina, and total oxygen.

Results indicated that graphitization could be closely correlated with deoxidation practice. Aluminum oxide formed during deoxidation, or produced in the steel by the oxidation of residual aluminum when the steel was heated in an oxidizing atmosphere for a long period of time, seemed to be the active nucleating agent. The other elements mentioned above did not appear to influence graphitization when present in the amounts found in the 18 steels, which were normal carbon steels. JLG (1a)

Hydrogen in Malleable Iron

"THE SIGNIFICANCE OF HYDROGEN IN THE METALLURGY OF MALLEABLE CAST IRON." H. A. SCHWARTZ, G. M. GUILER & M. K. BARNETT (Nat'l Malleable & Steel Castings Co.) *Preprint, Am. Soc. Metals*, Oct. 1940, 19 pp. Research.

The significance of the hydrogen content of white iron intended for conversion into malleable cast iron is studied at length. Until the development of a reasonably simple method for the quantitative determination of hydrogen, opinions on its effect were largely based on qualitative evidence or even on conjecture. White cast iron in a partially graphitized state will dissolve approximately twice as much hydrogen from a given atmosphere as will pure iron at the same temperature, according to Sievert's data. On a very meager experimental basis, there is no evidence that considerable hydrogen is adsorbed on graphite.

Commercial white cast iron may contain from about 0.0002% to 0.0010% H by weight. This hydrogen originates from rust in the charge and from moisture in the air and doubtless from other sources, such as the fuel. Oxidizing reactions during melting reduce the hydrogen content, but in general, the oxygen content of metal high in hydrogen is likely to be high, and vice versa, though not in any quantitative relationship.

The introduction of a small amount of almost any solid metallic addition into liquid white cast iron reduces the hydrogen content. On commercial annealing the hydrogen approaches a low constant value somewhat above 0.0001% regardless of the initial content. At room temperatures, white cast iron will absorb up to about 0.0015 weight % of hydrogen when used as the cathode in the electrolysis of water. At temperatures around 750° F. or over, white cast iron loses its hydrogen content to a hydrogen-free atmosphere slowly yet nearly completely.

Hydrogen from any source very greatly retards the graphitizing reaction. It does not seem to affect the "nodule number" of the resulting malleable cast iron but does seem to affect the migratory rate of carbon in solid solution, at least in gamma iron. White iron high in hydrogen as the result of melting practice produces iron of lower mechanical properties than iron lower in that element.

As a general statement, it may be said that hydrogen is, weight for weight, apparently the most potent element normally present in white cast iron in its influence on the properties of the metal. It is even possible that this statement is true atom for atom. EF (1a)

Continuous Strip Annealing

"STRAND HEAT TREATING COLD STRIP." NORMAN P. GOSS (Cold Metal Process Co.) & CURTIS H. VAUGHAN (Electric Furnace Co.) *Steel*, Vol. 107, Sept. 9, 1940, pp. 52, 54, 56-57, 72. Descriptive.

In batch annealing cold-rolled steel strip, directional properties cannot be removed if the metal has been subjected to reductions of over 50%. With continuous annealing at temperatures above A_3, heavy reductions are permissible, as the directional properties can be easily rectified because of the allotropic transformation taking place when strip cools through A_3.

An electric furnace for continuously annealing and normalizing 40 tons of low-carbon steel strip up to 36 in. wide in 24 hrs. is described. The furnace has an effective heating chamber 44 in. wide by 30 ft. long. A sectionalized cooling chamber

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separated about 10 ft. from the heating chamber is cooled by circulating water through a flattened helical pipe coil running throughout the 12-ft. length of the furnace. The heating and water-cooled chambers are connected by an insulated cooling section. The furnace atmosphere is generated from natural gas.

The strip is supported on a standard roller-hearth type of conveyor. Rollers in the heating chamber and in part of the cooling chambers are of heat-resisting alloy with polished surface; the remainder of the rollers in the cooling chamber are of brass. All rollers are individually driven. The surface speed of the rollers is identical with the rate of travel of the strip, eliminating the necessity of a rider sheet and the possibility of scratching.

Large savings in heating cost can be realized by the use of gas-fired radiant tubes. Assuming 1c per kwh., heating cost for an all-electric unit with capacity of 5 tons/hr. is $1.95/ton steel. For comparable equipment and assumed rate of 50c per 1000 ft.^{3} of natural gas, the cost with gas is 75c per ton. With a batch-type unit of 1 ton/hr. capacity, the cost with gas is 70c per ton. This small difference is reduced or eliminated by the reduction of scrap loss and elimination of coil set achieved by the continuous method. The initial cost of equipment is less on a "per ton" basis for continuous equipment than for batch.

The product of continuous heat treatment has uniform grain size and physical properties, and steels having unusual deep-drawing properties can be developed this way. Tests on a large number of coils of rimmed and killed strip steel normalized above A_3 proved that time at temperature controls the grain size. Only a few seconds at temperature are required to complete the recrystallization of the cold-rolled structure in either killed or rimmed steels.

Deep-drawing tests show that grain size, yield-point, uniformity of structure, and completeness of recrystallization are of more importance than hardness. Grain size can be controlled for all deep-drawing requirements by simply changing the speed of strip through the furnace; *i.e.* by varying the time held at temperature.

As the grains reach their maximum size in only a fraction of a minute, increasing time at temperature beyond a certain limit will not cause a further increase in grain size. Excellent deep-drawing properties are usually obtained when grains of aluminum-killed strip are about 0.0005-0.00075 in. diam.; for rimmed strip, the grain size should be slightly larger. If the strip is run through the furnace too fast, it will be unsuitable for deep drawing. MS (1a)

An idea that bore fruit

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Blast Furnace Desulphurization

THE DESULPHURIZING REACTIONS IN THE BLAST FURNACE ("Beiträge zur Kenntnis der Reaktionen der Entschwefelung im Hochofen") W. OELSEN & H. MAETZ. *Archiv. Eisenhüttenw.*, Vol. 13, May 1940, pp. 465-474. Original research.

The basic desulphurizing reaction is $FeS + CaO + C = Fe + CaS + CO$. The progress of this reaction is of significance for the metallurgy of pig iron not only at higher temperatures when the components are in the molten state but also while they are still solid.

The reaction was therefore studied by mixing the solid components, heating to temperatures from 1100° F. to 2900° F. and noting the loss in weight due to escape of carbon monoxide, and by taking thermal curves. The reactions with other oxides than CaO, such as SrO, BaO, MnO, MgO, Cr_2O_3 and SiO_2 were also studied.

With the alkaline earth oxides the reaction with FeS is exothermal and becomes active at temperatures below those at which the FeO formed is rapidly reduced by carbon (1650° to 1900° F.). With MnO the reaction with FeS begins at 1650° to 1900° F., hence much earlier than the reduction of MnO to Mn (2400° to 2650° F.). On the other hand, the reaction with MgO begins only above 2375° F. The reaction of Cr_2O_3 with FeS and C begins at about the same temperature as Cr_2O_3 alone is reduced by C.

It is notable that SiO_2 reacts very actively with FeS and C at about 2660° to 2700° F. with the evolution of thick fumes of the gas SiS. The reaction of MnS with CaO and C occurs at 2460° to 2730° F., at which temperature the reduction of MnO by C is rapid.

The reactions of the carbonates of the alkalies and alkaline earths with FeS and C were also studied as well as those of the double carbonate $CaNa_2(CO_3)_2$. With the alkali carbonates, both MnS and FeS are transformed to the alkali sulphides at the low temperatures of 1470° to 1830° F. The calcium silicates $CaO{\cdot}SiO_2$ and $2CaO{\cdot}SiO_2$ react with FeS and C only at much higher temperatures than pure CaO. In the case of $5CaO{\cdot}3Al_2O_3$ this increase in temperature is much less.

Tricalcium phosphate $[Ca_3(PO_4)_2]$ begins to react at the very low temperature of 2000° to 2280° F.; at the same time,

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the P_2O_5 formed is reduced and dissolved in the iron. Sodium pyrophosphate ($Na_4P_2O_7$) begins to react at 1750° to 2000° F., the P_2O_5 formed also being reduced at the same time. SE (1a)

1b. Non-Ferrous

Production of Die Castings

A Composite

Because die castings are produced not only by commercial die casters but also often by the same company that builds them into a finished product, these metal-forms are of the broadest kind of interest to metallurgical engineers. In addition to product design and casting design, careful attention must be paid to the purely production aspects, and in each case the engineers involved should be mutually familiar with all these problems.

In earlier issues of METALS AND ALLOYS we've examined the pros and cons of choosing die castings over other metal-forms for various finished products (see "When to Use Die Castings", Apr. 1940. p. MA 218) and studied the design of castings to get the most benefit from the die casting process (see "Designing for Die Castings", Aug. 1940, p. 214). Herewith we review some recent articles on the *manufacture* of die castings, to fill out the general picture.

Zinc Alloys

The automotive industry is the largest single user of zinc alloy die castings, and the Ternstedt Div. of General Motors Corp. therefore one of the largest producers. HERBERT CHASE ("Making Over 100 Tons of Die Castings a Day", *Machinery, N. Y.*, Vol. 47, Sept. 1940, pp. 101-105) describes the practice at this plant in making die castings of zinc alloy (S.A.E. No. 925—4% Al, 1 Cu, 0.04 Mg). About 46% of the charge is virgin; the rest is plant scrap.

Each heat is checked for fluidity, rate of solidification, melting point, oxide inclusions, hardness mechanical properties, and analysis (spectroscopically, especially to make certain tin, lead and cadmium are below the maximum permitted). Several of the machines average as much as 400 shots an hour, through the aid of automatic pushouts. Some inserts are cast in place, while others are fed into the die automatically.

Rejects are not returned directly to the furnace, as the steel insert would appreciably increase the iron content of the casting. Instead, any unsatisfactory die castings are passed through a gas flame in jaws that grip the steel insert; the zinc alloy melts, drops off, and is returned to the furnace; the steel insert is pickled in hydrochloric acid to remove all traces of zinc, and returned to the die casting machine for reuse.

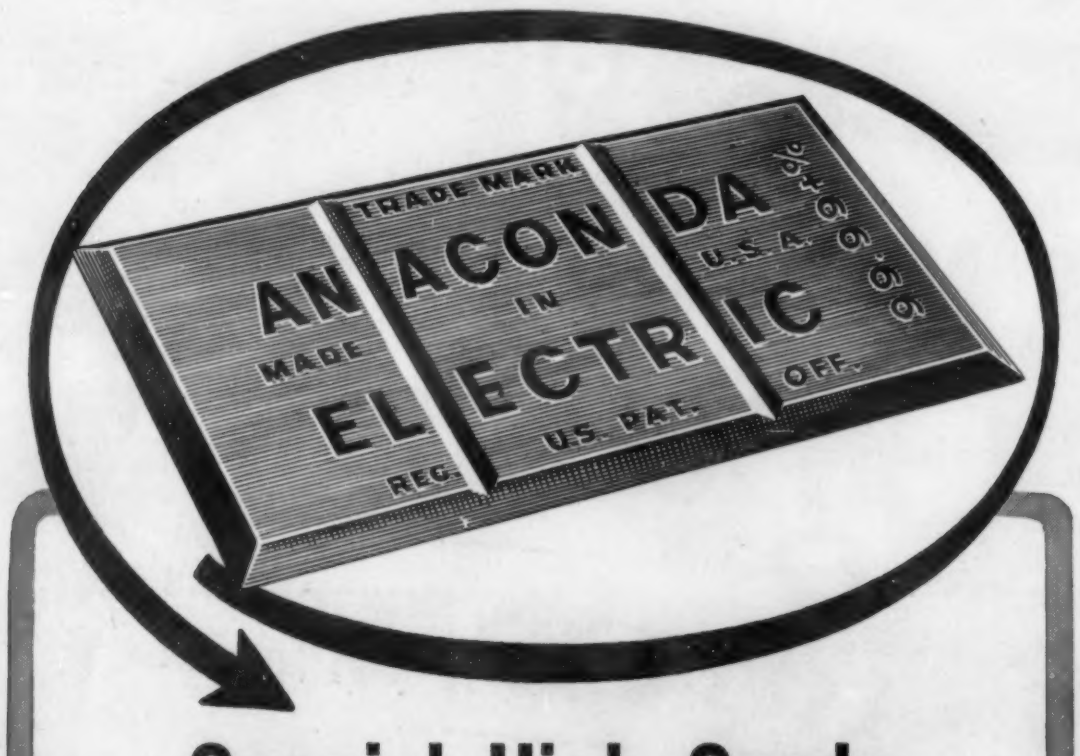
The advantages and disadvantages of using inserts are examined for various circumstances in another article ("Increasing the Utility of Die Casting by Inserts", *Machinery, N. Y.*, Vol. 47, May 1940, pp. 110-113). Inserts must be placed in the hot die, which slows up the cycle and increases costs. On the other hand, they are a great design aid. Thin walled tubes, gears, and gear segment inserts are used to increase wear resistance. Steel inserts are often plated to avoid rusting; if inserts are to be used in zinc alloy die castings, the plating should preferably be high purity zinc, and never cadmium, tin or lead.

Shrinkage figures of value to die casters are given in a brief article in *Machinery, London* ("Contractions of Die Castings", Vol. 56, May 9, 1940, p. 196). Zinc-base alloys generally contract 0.0075 in. per diametral or linear in. on cooling from casting temperature to room temperature. The steel mold contracts about 0.0025 in. per in. Therefore, designers of die castings allow about 0.005-0.006 in. per in. for contraction. Similarly, about 0.008 in. per in. is the figure used for aluminum.

The production practice used by Doehler Die Casting Co. in die casting motion picture projector frames of zinc alloy is beautifully presented in a pictorial article by VAN FISHER ("Die Casting—The Manufacture of a Projector Frame", *Metal Progress*, Vol. 38, Sept. 1940, pp. 275-283). Melts are 2½ tons each, and are made by adding aluminum and magnesium shot to molten 99.99% pure zinc in a gas-heated cast iron pot, superheating to 850° F., and skimming. The melt is then transferred to the die casting machine, where a single-action pump is submerged in a tank of liquid alloy, whose outlet is connected to the cavity, properly shaped in water-cooled steel die blocks.

The pump plunger drives molten zinc at 2000 lbs./in.² into the cavity, completely filling it. The metal chills in seconds, the die reopens a set time, carrying the hot castings with it, but is loosened en route by a number of ejector pins. About 300 castings an hour can be made if they have no heavy bosses or thick sections.

Zinc alloys are easier on the dies than aluminum or copper alloys. Die steels are chiefly of the 5% Cr variety; ejector pins



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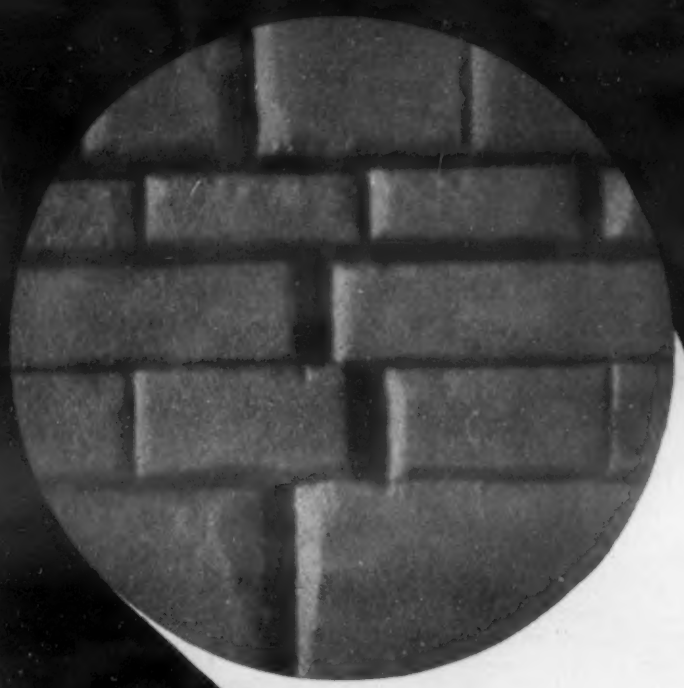

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are made of cutlery-type stainless steel, hardened and nitrided. Accurate dimensions stem from the accuracy of the casting die, trimming die and jigs for threading and boring, and extremely little "finishing" is necessary on a well-made casting.

Still another large plant, and its equipment and practice for making zinc alloy die castings, are described by HERBERT CHASE ("New Die Casting Plant", *Steel*, Vol. 106, May 20, 1940, pp. 70-71, 80). The new plant—Alemite Die Casting & Mfg. Div. of Electric Autolite Co.—features volume output and mechanization. Melting furnaces of 5,000 lb. capacity are located near the casting room, to which they are connected by a monorail conveyor fitted with hoists carrying a tilting ladle. A belt conveyor returns sprues, gates and flash to the melting furnaces. The machine tools used for fin removal are movable—a big aid to "finishing" lineup.

Light Metal Die Castings

Die castings of aluminum and magnesium alloys are increasing in application as a direct result of mounting aircraft production. The present status of aluminum alloy die casting manufacturing progress is mentioned by D. L. COLWELL ("Die Casting as a Production Aid", *Metal Progress*, Vol. 38, Oct. 1940, pp. 532-533). An outstanding advance is the availability of the new "cold chamber" die casting machines, in which contact between molten metal and die steel is only momentary and the iron pickup by the aluminum alloy is therefore nil. With the conventional gooseneck machines, of 600 lbs./in.^{2} maximum pressure, the iron gooseneck was a source of contamination, often as high as 0.3% Fe with each melting. With the new machines pressures up to several thousand lbs./in.^{2} can be used.

Magnesium alloy die casting practice and applications are reviewed in a British magazine (("Pressure Die Casting of Magnesium Alloys", *Machinery, London,* Vol. 56, June 6, 1940, pp. 316-318). The low viscosity of molten magnesium alloys aids the production of thin-walled complex castings. Magnesium is less corrosive than molten aluminum, so die life is said to be 50-60% higher than for aluminum. If close limits are specified, die life is about 40,000-100,000 pieces, while about 500,000 castings may be obtained if dimensional tolerances are broader. Dies are usually chromium-tungsten steel hardened to 38-42 Rockwell C.

Additional data on magnesium alloy die casting are found in an article by E. RICHARDS ("Magnesium Alloy Die Casting", *Can. Metals & Met.*. Inds., Vol. 3, Mar. 1940, pp. 78, 80). The minimum weight for intricate castings is about 0.35 oz., while that of a more simple design may reach 0.07 oz. if cast in multi-sectioned dies. Accuracy of dimensions is said to be greater than with aluminum alloy die castings—the general allowance amounting to about 0.15-0.20% at an absolute minimum of 0.004 in. X (1b)

Making Smooth Copper Wire

"DUSTLESS AND SLIVERLESS WIRE." W. H. BASSETT, JR. (Anaconda Wire & Cable Co.) *Iron Age*, Vol. 146, Sept. 5, 1940, pp. 36-39. Practical.

Smooth, dustless and sliverless wire is currently produced in several ways: (1) Standard scalped wire bar is hot-rolled, draw-die-scalped and drawn; (2) end-poured wire bar is hot-rolled, draw-die-scalped and drawn; (3) oxygen-free or deoxidized high-conductivity wire bars are hot-rolled, draw-die-scalped and drawn; (4) coalesced cathodes are extruded into rods and drawn to required size; (5) standard copper billets are extruded into rod and drawn; and (6) oxygen-free or deoxidized, high-conductivity copper billets are extruded into rod and drawn.

The selection of the type of wire depends on the economics of the individual situation and on the requirements of the user. At the present time, electrical apparatus manufacturers favor the use of die-scalped rods. Advantages claimed are greater uniformity in the original copper castings, improvement of hot-rolled rod, and resulting refinement of fabricating operations.

Starting with a superior casting, the difference in quality of copper wire is more readily demonstrated by examining hard-drawn material. Tensile strength and elongation tests are not critical enough to show a marked difference in hard copper line wires produced from different types of wire bars. Special tests, however, do demonstrate difference in quality.

Oxygen-free copper shows greater resistance to fracture when subjected to right-angle bends. Scalped, end-poured and oxygen-free wire bars offer greater resistance to fracture under torsional stress because of their more uniform surface. The surface characteristics show up differently when the wire is subjected to the warp test. Samples will show surface cracks in "set" (area of oxide concentration) when bent severely.

In die-scalping copper rods, the surface is removed in the same manner that the

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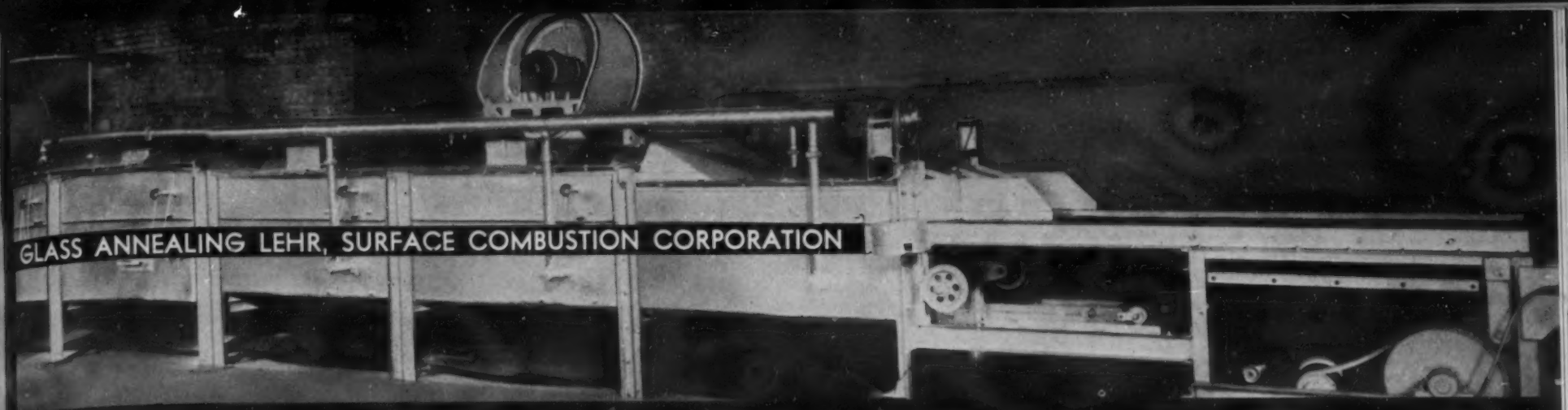
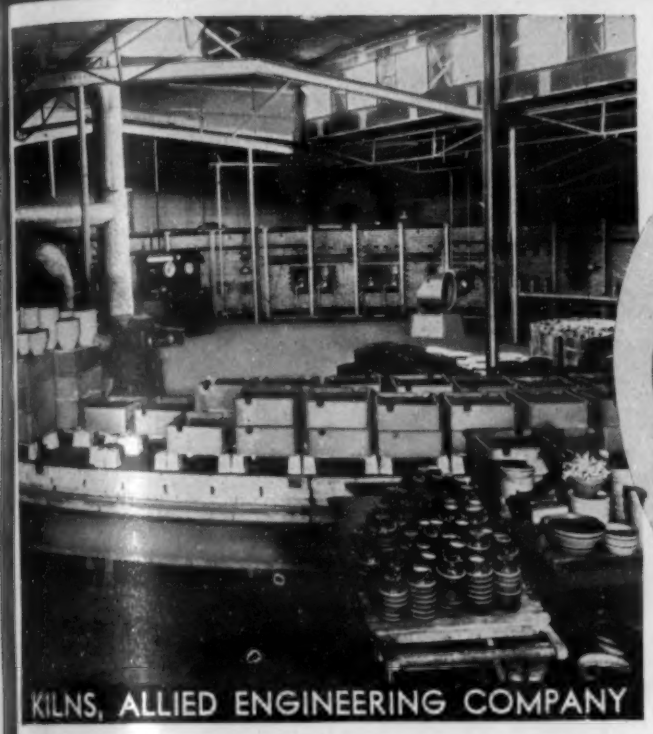


GLASS ANNEALING LEHR, SURFACE COMBUSTION CORPORATION

CERAMIC APPLICATIONS



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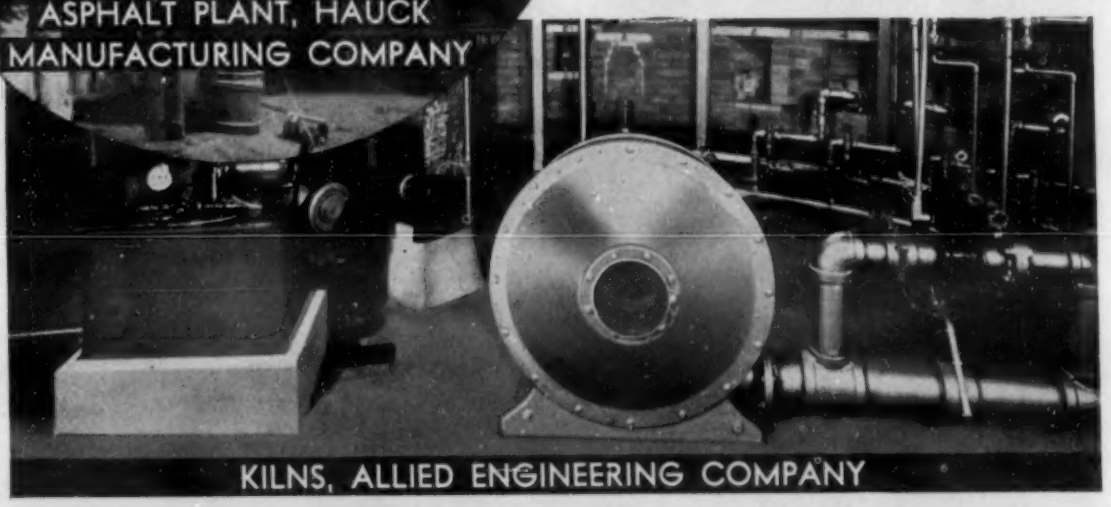

KILNS, ALLIED ENGINEERING COMPANY

Heating operations in the ceramic field have many points in common with the heat treating field. For one thing, many of the equipment manufacturers that have developed modern heat treating equipment also furnish equipment for lehrs, kilns, enamel ovens and miscellaneous heating units.

In common with heat treating, a smooth continuous flow of clean dry air is essential for close control and perfect timing.

Also, as in heat treating, the majority of equipment manufacturers in the ceramic field prefer and recommend Spencer Turbo-Compressors.

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skin is peeled from a banana. Removal of metal from the surface of the rod eliminates rolling defects and produces a wire free from burrs, slivers, seams, laps, fins and dust. Magnet wire produced from the "perfect-surface" rods (double-scalped) is especially suited to the requirements for copper windings in transformers, motors, generators and coils used in utility, air conditioning, transit and other industries.

VSP (1b)

Patterns for Non-Ferrous Foundries

"Patterns and Pattern Design for Non-Ferrous Foundries." *Foundry*, Vol. 69, Aug. 1940, pp. 33, 106-109. Practical.

Non-ferrous patterns and pattern design do not receive sufficient attention. Patterns are often produced with undue haste and therefore the finished castings require excessive machining at the expense of material waste and machine shop costs. The best pattern can be determined by conference between the designer or user of the casting and a competent foundryman.

The A.F.A. has established a standard method of coloring patterns. There are colors for surfaces that must have allowance for machining and for core prints, to avoid confusion as to whether part of the pattern is boss or core print, and other details.

In producing the first or single pattern of a part, it may seem economical to make a cheap pattern. However, where there is likelihood of distortion by warpage or where a number of castings are to be made from a cheap pattern, the change of dimensions caused by the use of poor lumber may result in rejected castings. Therefore, single patterns should be made of well dried, preferably hard, wood, properly laminated from several thicknesses of wood. Core boxes should also be made of dried wood.

Where a number of castings are to be produced, the surface should be sheathed over with metal so that striking off the cores will not wear the surface. The use of skeleton patterns is not advisable. Sweep core boxes are satisfactory where design is not too intricate and where the accuracy of wall thickness is not a likely cause of rejection. Good patterns must be made so that they can be molded in the proper position to permit attachment of risers where needed.

Matchplates are often used in mass production. However, due allowance must be made for shrinkage during the casting of the matchplate as well as the shrinkage of castings. The surfaces of matchplates must be smooth and clean, which means they must be cast in fine sand. Metal matchplates are much better than wooden. Wood patterns mounted on metal matchplates sometimes will give satisfactory results if the patterns are surfaced with steel or bronze where they receive the most wear.

In designing a matchplate for a gate of patterns, provision must be made for the proper flow of metal to runner and gates and to the casting cavity. At the same time the patterns must be located in the flask in such a way that in making the sand mold uniform ramming conditions may be maintained to eliminate distortion of the casting. Also, enough sand should surround the risers or sprues to prevent break-out under pressure of the weight of metal.

VSP (1b)

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(U. S. Patent No. 2,134,670)

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1. Resistant especially to the highly corrosive solutions of hot, weak sulfuric acid, such as used for pickling; to solutions containing oxidizing agents, such as iron sulfate, copper sulfate, nitric acid.

2. Resistant to the high corrosive solutions of caustic soda at all temperatures, and to other alkaline solutions.

3. Excellent physical properties:

Ultimate strength	65-75,000 p.s.i.
Elongation, % in 2"	35 - 50
Hardness—Brinell	130 - 150
Machinability	50-75% cast carbon steel
Welding Properties	Good

Available to you as:

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(c) — Finished castings
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Continuous Casting

"Production of Strip by the Myasoyedov Brothers' Method of Direct Continuous Casting and Rolling." A. N. Myasoyedov & A. N. Myasoyedov. *Tsvetnye Metally*, No. 10-11, Oct.-Nov. 1939, pp. 153-166. In Russian. Research.

The authors investigated the possibilities in direct rolling of metals without intermediate casting into ingots. In their first experiments, lead was chosen because of its low melting point.

The metal is melted in an electric furnace from which it flows into a reservoir maintained at a definite temperature. From there it enters a "crystallizator," which is a tube 60 m. long and 6 mm. in diam., open at the other end. A stream of cooling water is adjusted so as to solidify the metal as it leaves the "crystallizator." As the metal solidifies, it enters a set of rolls as a continuous bar. Using the laboratory model, a strip of lead 10 meters long was obtained.

Following these experiments, an apparatus was designed and constructed for direct rolling of brass. The "crystallizators" were made in various sizes up to 8 cm. in diam. Adjustable rolls were built capable of developing continuous variation of strip movement from 0.5 to 32.0 meters/min. The process is regulated by synchronization of the rate of cooling of the metal and the speed of the rolls.

The preliminary tests with lead gave very good results. Further tests are planned for the direct rolling of brass, copper and aluminum.

BND (1b)

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Protective Coatings

A Composite

"Save the Surface and You Save All" is a familiar advertising slogan that is just as applicable to metal-corrosion problems as to house-painting. Protective coatings of either a metallic or non-metallic nature are the metallurgical engineer's way of saving his "all", the underlying metal, and of achieving economically long service life with inexpensive basis materials.

A group of papers given at the recent annual meeting of the Am. Soc. for Metals presented the latest development in 5 most important metal-coating fields—galvanizing, tinplate, surface treatment of stainless steel, anodizing aluminum alloys, and finishing magnesium alloys.

Galvanized and Tinplate

The various methods of producing zinc coatings on steel by hot-dipping and electrogalvanizing are analyzed from the standpoints of unit operations, equipment, cost, metallurgical structures obtained in the coating, corrosion resistance, equality advantages and testing by J. L. BRAY of Purdue Univ. and F. R. MORRAL of Continental Steel Corp. ("Zinc Coatings—Unit Operations, Costs and Properties", *Preprint, Am. Soc. Metals*, Oct. 1940, 9 pp.).

In contrast to hot-dipping, electrogalvanizing can be easily applied on tempered and high-carbon steels. Defects on the steel surface are revealed in electrogalvanizing, and much heavier coatings of zinc can be applied with that process. These heavier possible coatings are of great practical importance, since the life of the coated steel article bears a direct relation to the weight of the coating and its uniformity, particularly for sheets. Thickness and uniformity can be accurately controlled in electroplating, except on very irregular shapes, and paint can be applied to electro-galvanized sheets without any preparation.

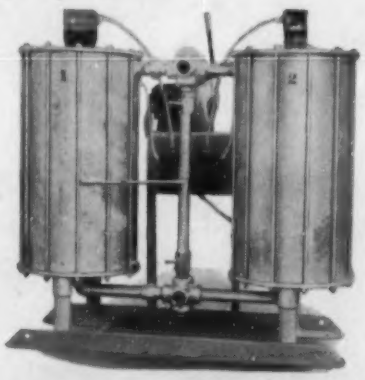
It is often claimed that the electrolytic zinc coating is absolutely pure, and, therefore, should be more corrosion resistant. While this is true for certain conditions, such as resistance to dilute sulphuric acid, a hot-galvanized sheet or wire may be more resistant to atmospheric corrosion. Effects such as the elimination of zinc losses by drossing have been mentioned as favorable to electrogalvanizing, but in electroplating there is a considerable loss of power, which may offset this advantage. Furthermore, while the wire may be passed through the electrolytic bath at higher speeds than can be used in hot-dipping, up to the present time these higher speeds have not been commercially utilized.

Tinplate problems are of obviously great importance, but in the "defense" picture their importance is much magnified, for an army moves on its tin cans, to paraphrase an old truism. The service life of tinplate containers, particularly as affected by the steel base composition, has been comprehensively investigated by R. R. HARTWELL of American Can Co. ("Corrosion Resistance of Tin Plate. Influence of Steel Base Composition on Service Life of Tin Plate Containers", *Ibid.*, 34 pp.). Over a period of several years experimental packs of acid food products of the more corrosive type have been made and correlation of the time required for failure of the containers by corrosion with the analyses of the steel base has been made.

The presence of increasing amounts of phosphorus in the steel base for enameled tin cans results in rapidly decreasing corrosion resistance. In plain cans, the effect of phosphorus is much less marked. Hydrogen-evolution tests provide an indirect, commercially satisfactory means of measuring the effect of phosphorus. For maximum resistance to acid corrosion, the use of tinplate with a low-phosphorus steel base is suggested.

Increasing amounts of copper (enameled cans) may either reduce or enhance the corrosion resistance, depending on the nature of the product packed. For strongly corrosive products, it is thought that a steel base low in copper and phosphorus is most desirable. While a high copper content increases the life of cans for a few products, its general use would result in very early corrosion losses for others.

The presence of silicon in steels with a



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high-phosphorus steel base is undesirable. Silicon seems to have a larger effect on the corrosion resistance of plain tin cans than any other element, the influence being at least in part due to some effect on the base metal that favors the formation of small cracks when the plate is deformed. Tin plate made from silicon-killed steel is thus considered unsuitable for use in fruit packing.

It has not been possible to demonstrate that the manganese, sulphur and carbon content of tinplate, within the ranges usually encountered, are major factors influencing the corrosion resistance. Tinplate manufactured from "pure iron", however, possesses excellent resistance to the action of one of the most corrosive fruit products packed. There is some indication that the presence of nickel and chromium in relatively large amounts may be detrimental to corrosion resistance in certain instances.

Stainless Steel Treatments

A useful summary of current views and practices with respect to surface treatments for stainless steel is given by G. C. KIEFER of Allegheny Ludlum Steel Corp. ("The Passivation and Coloring of Stainless Steel", *Ibid.*, 13 pp.). Passivation is not a constant state or an inherent property, but may apply only to certain environments or conditions; even when a metal or alloy is passive under a given set of conditions a slight change in these conditions may destroy the protective film and so change the metal from the passive to the active state.

The influence of a protective film on the corrosion resistance of alloys of chromium and iron is more marked than with other alloys. The addition of molybdenum to chromium alloys and chromium-nickel alloys aids passivation, particularly in strengthening and stabilizing the protective film in non-oxidizing acids and in environments where partial destruction of the films is likely to occur.

The art of coloring stainless employs methods that follow very closely those used on the more common metals and alloys. The application of enamels and japans to etched surfaces of stainless, electroplating with copper, molybdenum, chromium and manganese followed by oxidizing, and the Bach and Coloron processes are briefly discussed. Much secrecy surrounds most coloring processes and little is known yet about the performance of colored stainless steel under various testing and service conditions.

Finishing Aluminum and Magnesium

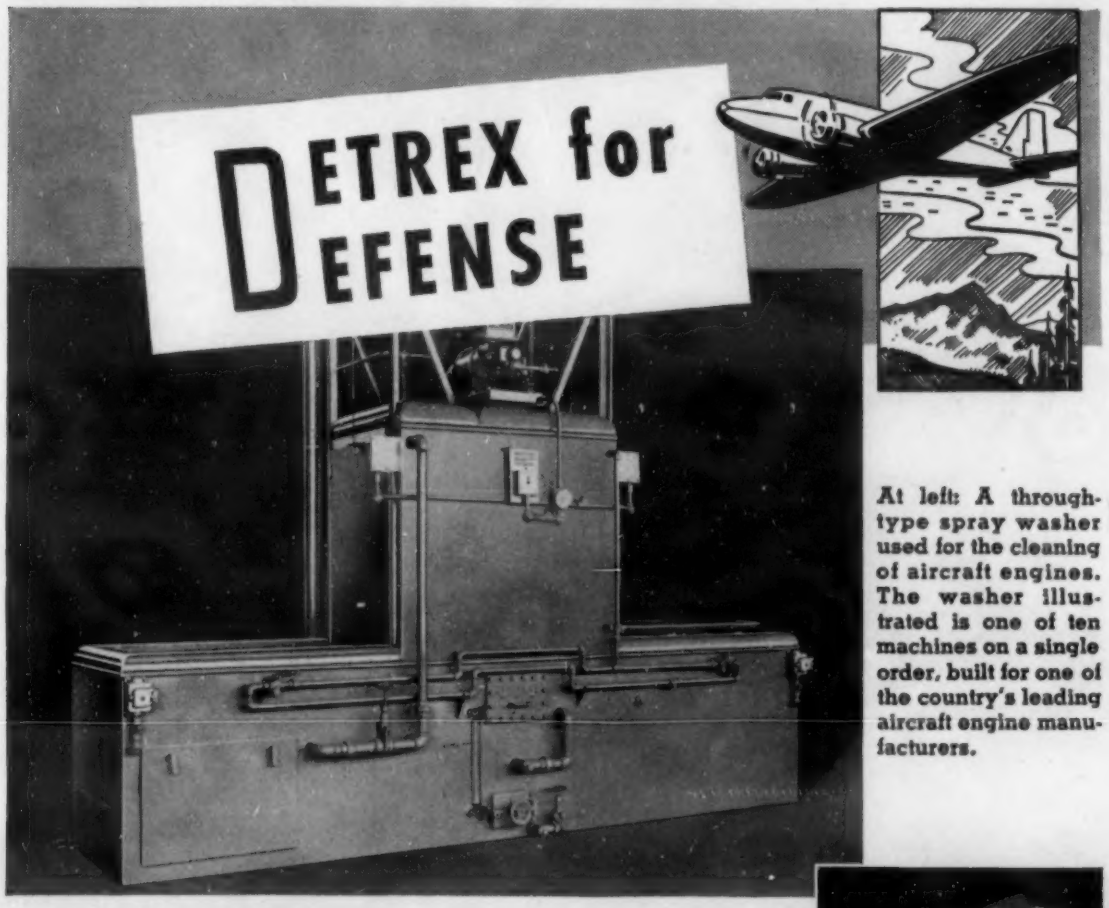
Among general finishing developments, few have been more spectacular than those associated with the light metals aluminum and magnesium. The field of anodic treatment of aluminum and its alloys is reviewed by JUNIUS D. EDWARDS of the Aluminum Co. of America ("Anodic Treatment of Aluminum", *Ibid.*, 15 pp.). By anodic oxidation in electrolytes such as dilute solutions of sulfuric acid, oxalic acid or chromic acid, oxide films of thicknesses of 0.0001 to 0.0006 in. can be commercially applied. Although these films are all essentially aluminum oxide, varying the conditions of application can give them a wide range of properties in respect to color, hardness, porosity, and protection against corrosion.

In the anodic treatment of aluminum-alloys, the various constituents may be selectively dissolved or oxidized and occluded in the oxide coating. The adsorptive characteristics of the oxide coating are most strikingly illustrated by their ability to absorb and hold dyes. Various methods are available for sealing oxide coatings so as to make them nonadsorptive and stain-proof.

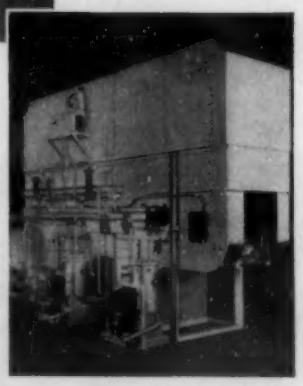
Aluminum can be electrolytically brightened or polished by anodic treatment in an electrolyte such as fluoboric acid. With the variety of processes available for applying and modifying the characteristics of oxide coatings, these coatings have become important in extending the commercial applications of aluminum and its alloys. Among the properties of anodized oxide coatings, the author dwells upon composition and structure, appearance, thickness, adsorption, sealing, resistance to abrasion and electrolytic brightening or polishing.

Extension of application of magnesium alloys—particularly in one of their potentially greatest markets, the aircraft industry—depends on their surface protection, for magnesium alloys are but poorly resistant to salt-water or salt-air corrosion. Various practical and satisfactory means of protection have been developed in recent years, and these are broadly reviewed by H. W. SCHMIDT, W. H. GROSS & H. K. DELONG of Dow Chemical Co. ("The Surface Treatment of Magnesium Alloys", *Ibid.*, 28 pp.). Operating technique and data on corrosion resistance and paint adhesion properties of all modern chemical treatments are discussed.

The evaluation of a surface coating is a complicated problem. Tests such as salt spray, periodic wetting by salt water, total



At left: A through-type spray washer used for the cleaning of aircraft engines. The washer illustrated is one of ten machines on a single order, built for one of the country's leading aircraft engine manufacturers.



A conveyorized Vapor-Spray-Vapor Degreaser used for cleaning component parts of aircraft engines.

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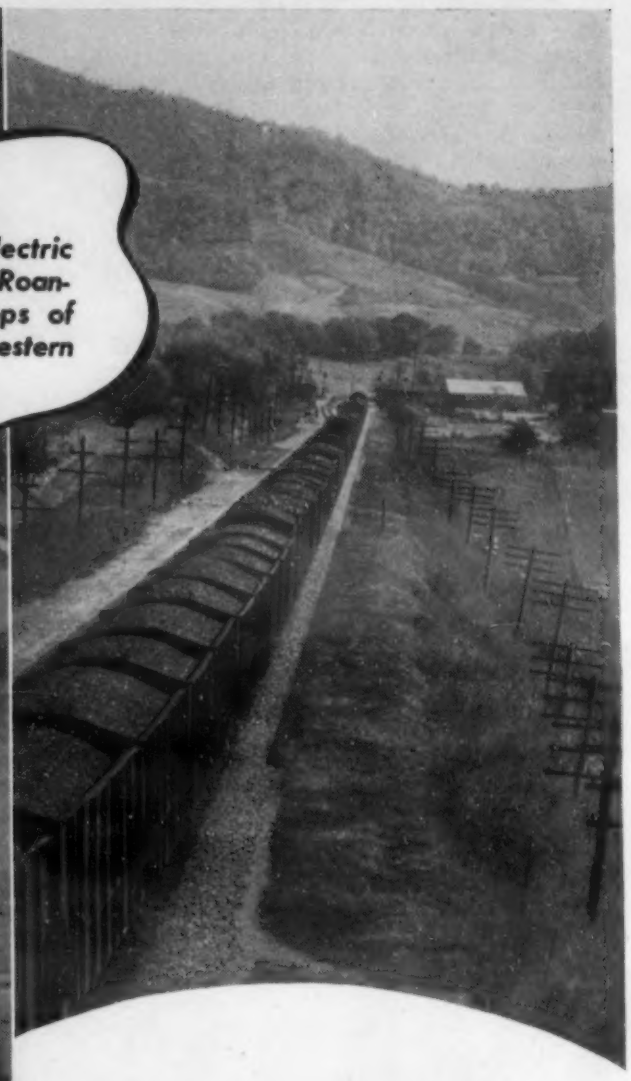

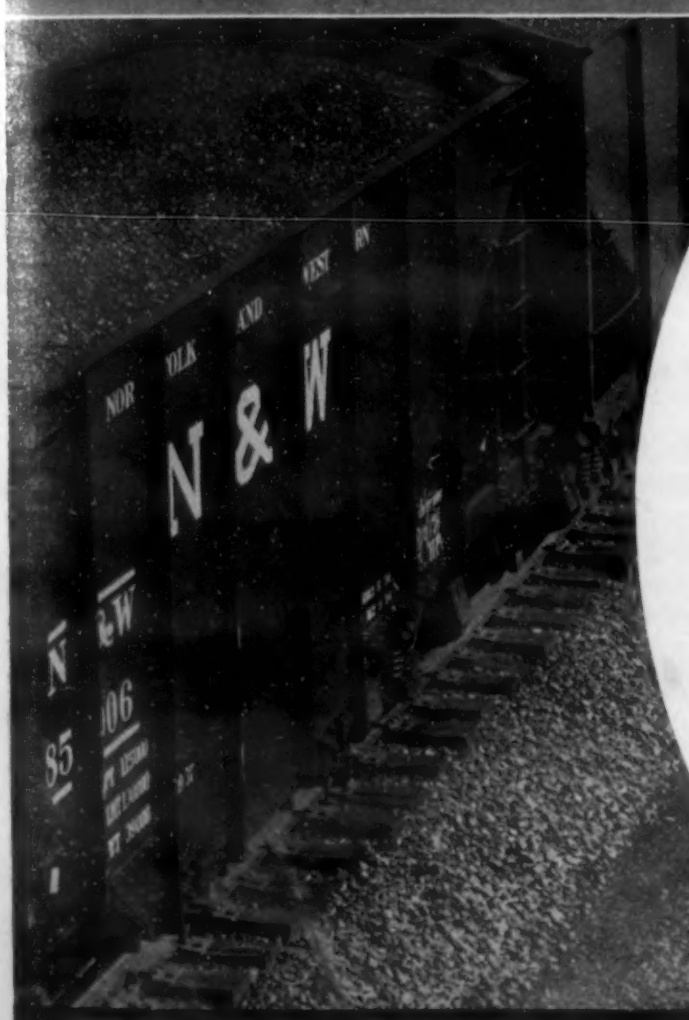

N & W *and* HEVI DUTY *furnaces*

Among important Hevi Duty Electric Furnaces in the Roanoke Shops of the Norfolk & Western Railway is the Hevi Duty Electric Carburizer used for carburizing pins and bushings in car construction. Quality and economy were important factors considered in their choice of this equipment.

HEVI DUTY ELECTRIC COMPANY

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or alternate immersion in salt water give relative understanding of the protection factor. Most materials are used in the painted condition, and prolonged atmospheric exposure (a year or longer) is recommended when flexibility and durability of the paint coating are to be determined.

Test results on a standard magnesium alloy containing 6% Al, 3 Zn, and 0.1 Mn show the need for some form of acid pickling prior to chemical treatment when the surface has been cleaned by sand-blasting. Dichromate treatment (Dow No. 7), alkaline dichromate treatment (Dow No. 8) and galvanic anodizing (Dow No. 9) are the best treatments for magnesium-aluminum-manganese-zinc (Dowmetal H) alloys. For magnesium-manganese (Dowmetal F) alloys a chrome-pickle (Dow No. 1) or galvanic anodizing (Dow No. 9) is recommended.

Where maximum abrasion resistance is required, the best chemical treatment is the caustic pressure treatment (Dow No. 6). Where electrical resistance must be at a minimum, as in the case of electrical bonding on aircraft, the chrome-pickle (Dow No. 1) and chrome-sulphate (Dow No. 11) treatments are satisfactory. EF (2)

Chain-Belt Conveyor Furnaces

"Chain-Belt Furnaces—Their Design, Construction and Application." W. F. Ross (Electric Furnace Co.) *Heat Treating & Forging*, Vol. 26, Sept. 1940, pp. 457-460; Oct. 1940, pp. 507-510. Descriptive.

Continuous chain-belt conveyor furnaces are used for heat treating a variety of materials and small-to-medium size parts not amenable to advantageous handling in other types of continuous furnaces.

The continuous endless belt is supported at each end of the heating chamber upon a rotating drum and carries material into and through the chamber on the upper belt flight. The furnace size may be materially decreased by returning the lower belt flight within the furnace chamber, thereby conserving heat in the belt and practically eliminating heat-to-tare loss after initial heating-up.

At the charging end, there is an extended loading platform, consisting of a continuation of the furnace chamber proper and below the level of the upper flight of the conveyor. The charging drum is located in this extension, which is arranged to house and insulate completely all but a short exposed section of the belt between the charging drum and furnace door.

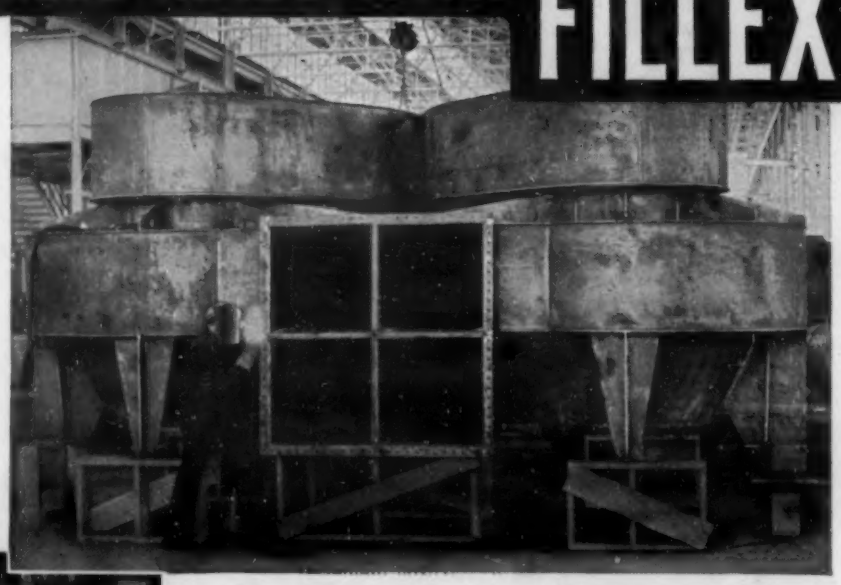
The usual discharge method utilizes a vertical chute located under the discharge drum and extending downward through the furnace hearth into the quenching liquid. When parts such as small gears are to be quenched, and defacement would be objectionable, the discharge arrangement utilizes a stripper plate, which removes material from the conveyor and passes it down an inclined chute through the rear end wall of the furnace into the quench.

For hardening treatments, belts made of alloys containing 35-40% Ni. and 15-17% Cr are used. For drawing temperatures below 1000° F., belts constructed of cast iron, nickel cast iron or malleable iron may be used. Belt fabricated from a large number of small accurately machined links is preferable to the same size belt fabricated from a relatively small number of much larger links.

The nickel-chromium alloy support drums are of special design, accurately machined to present teeth at staggered intervals, and of proper pitch to engage the belt across its entire width. The conveyor is driven through the discharge end support drum. As a special atmosphere is often used within the furnace, the latter is usually inclosed in a welded, gas-tight steel shell, provided with a very close-fitting door at the charging end. The furnace lining consists of a facing of insulating refractory brick backed up by graduated insulating brick.

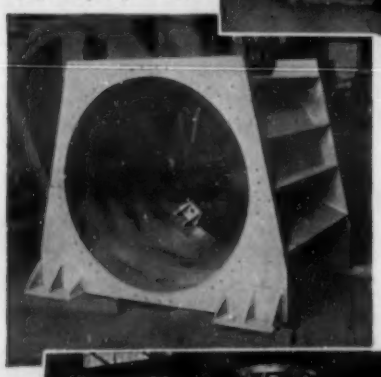
The furnaces may be heated by various means—electrically through nickel-chromium alloy grid-type elements, suitably suspended; and (where scale-free production is not required) by direct firing with high- or low-pressure gas or fuel-oil. The muffle-type chain-belt furnace is usually direct-fired; the heat-resisting alloy muffle within the furnace completely encloses the upper belt flight except at the discharge end. MS (2)

YOUR HORIZONTAL FILLETS WILL COST LESS MADE WITH FILLEX



Dust collectors Murex-welded by American Blower Co., Detroit, involve many Fillex applications.

Fillex speeds fillet welding like that in this air test assembly, Murex-welded by The Graves-Marshall Co., Dayton, Ohio.



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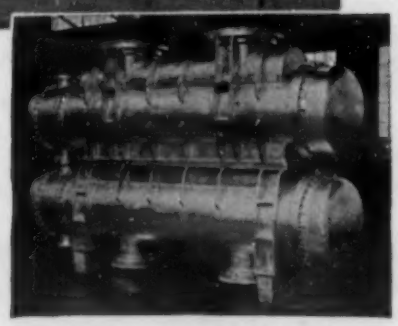
Specially designed for high speed horizontal fillet welding, Murex Fillex Electrodes help reduce welding costs.

Even at high amperages, Fillex Electrodes produce sound, evenly proportioned fillets without undercutting and with a minimum of spatter. Slag is easily removed, resulting in real savings in time on multi-pass work. Weld surfaces are smooth and welds require little or no cleaning.

Write and ask to have Fillex demonstrated on your horizontal fillet welding applications.



Fillets in these Murex-welded petroleum condensers, built by Ross Heater Co., Buffalo, are typical of Fillex welds.

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2a. Ferrous

Hardenability of Steel

A Composite

Every National Metal Congress in recent years has brought forth several papers on the hardenability of steel, for this general topic is of the greatest significance to heat treating engineers everywhere. The problem has been approached in a variety of ways, from the standpoints of workpiece size and shape, of quenching media and cooling rates, of hardening temperatures, of austenitic grain size, of alloying constituents, and many others. Hardenability testing methods have been developed and examined, and even the definition of the

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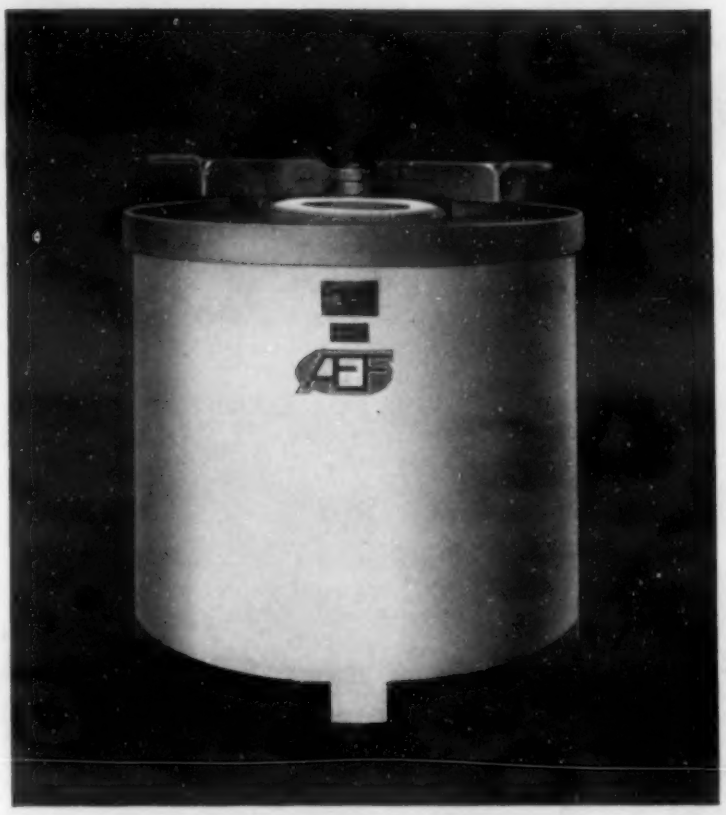

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word is still a subject for discussion. This year's A.S.M. convention was no exception, as the following review of several "hardenability and transformation" papers indicates.

Grain Size Effects

Continuing their studies, which had previously shown that alumina may serve as a graphitizer during prolonged heating, CHARLES R. AUSTIN & M. C. FETZER of Penn. State College ("Cementite Stability and Its Relation to Grain Size, Abnormality and Hardenability", *Preprint, Am. Soc. Metals,* Oct. 1940, 13 pp.) report on the correlation between carbide stability (or tendency to graphitize) and fracture grain size at various temperatures, McQuaid-Ehn grain size and abnormality, and hardenability of 18 nominally similar hypereutectoid steels.

The tempering studies were made in covered lead at 1240°F. for periods up to 600 hrs. on specimens quenched from 1830°F. In general, the results indicate that coarse-grained normal steels are stable while the fine-grained abnormal steels graphitize. Alumina, which may have such a profound effect on the control of grain size and abnormality, may similarly markedly lower the stability of the carbide.

The effect of aluminum on hardenability was also the concern of G. U. CASH, T. W. MERRILL & R. L. STEPHENSON of Carnegie-Illinois ("Effect of Deoxidation on Hardenability", *Ibid.,* 6 pp.), who made several coarse- and fine-grained ingots from the same heats of steel, by varying the deoxidation practice in the mold and in the ladle. The hardenability of a steel appears to be a function of its composition and its grain size *when hardened,* and the deoxidation practice affects hardenability only as it determines the temperature at which a particular grain size may be established, or as it affects the grain size established at a chosen temperature.

With the buck thus passed to the grain size, M. A. GROSSMAN & R. L. STEPHENSON of the same company ("The Effect of Grain Size on Hardenability", *Ibid.,* 13 pp.) investigated the effect of austenitic grain size on the hardenability of steels of various compositions, the grain size being varied by changing the quenching temperature. It was found that the greater the hardenability of the steel by virtue of its composition, the more was its hardenability affected by grain size.

The austenitic grain size established at different temperatures with various rates of heating through the transformation range was determined for pure iron-carbon alloys and for several steels by S. J. ROSENBERG & T. G. DIGGES of Nat'l. Bur. of Standards ("Effect of Rate of Heating Through the Transformation Range on Austenitic Grain Size", *Ibid.,* 28 pp.). For the high-purity iron-carbon alloys containing 0.5% C, the grain size between 1475° and 1600° F. increased with decrease in rate of heating. Coarser grains were produced at the lower temperatures with slow heating rates than at higher temperatures with fast ones.

In the 1.01% C steel, the grain size at 1600° F. increased but slightly with decrease in heating rate. At a carbon content of 1.21%, the rate of heating had no significant effect on the grain size at 1800°F. The rate of heating affected the grain size at 1475° F. of the commercial 0.49% C steels with both "non-controlled" and "controlled" grain size, and at 1600° and 1800° F. with the "non-controlled" steel. The grain size of these steels tended to increase with increasing heating rate.

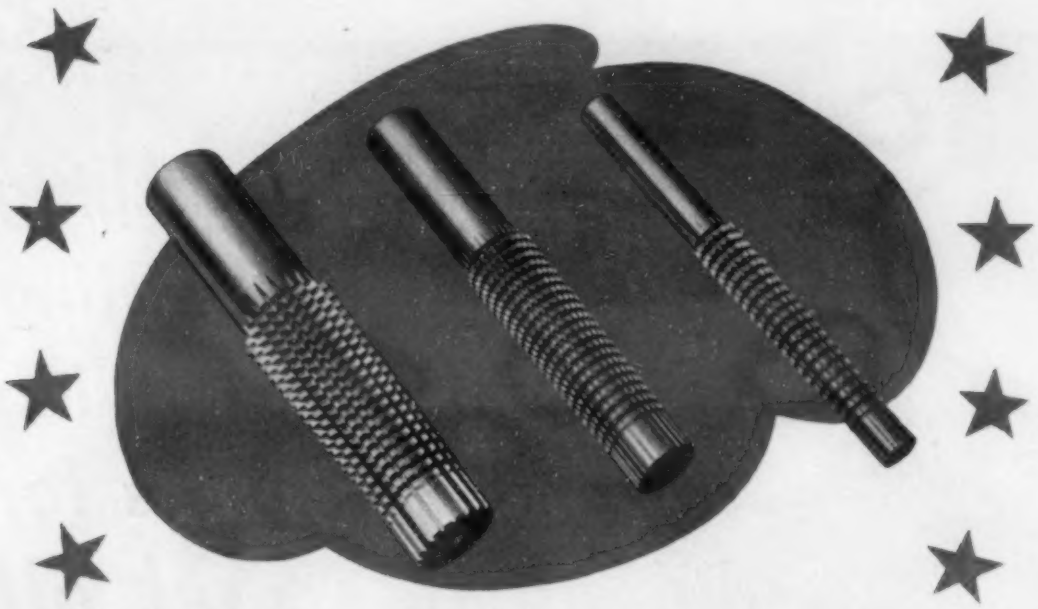
With the "non-controlled" 1.05% C steel, the heating rate did not affect the grain size at 1650° and 1800° F., but it did in the "controlled" steel of similar carbon content at the same temperatures. At the lower temperature, the coarsest grains were produced with an intermediate rate of heating, whereas at the higher temperature, the coarsest grains were produced with the slowest heating rate. With the experimental 0.5% and 1% C steels the grain size at 1600° F. was not influenced by the heating rate.

DIGGES ("Influence of Austenitic Grain Size on the Critical Cooling Rate of High Purity Iron-Carbon Alloys", *Ibid.,* 31 pp.) also studied the effect of grain size on hardenability. The critical cooling rate progressively decreases (hardenability increases) as the austentitic grain size increases in steels with 0.80-0.85% C. For each austenitic grain size studied, the critical cooling rate decreases continuously with increase of carbon content.

The maximum hardness values obtained on quenching from 1800° F. increase with rising carbon contents up to 0.70%, remain constant at 0.70-0.85% C and then decrease again slightly. Variations in cooling rates between 360° and 1775° F./sec. with austenitic grain size of 20 grains/in.^{2} at 100X have no appreciable effect on the temperature range of the start of the Ar″ transformation in the 0.80% C alloy. Variations in austenitic grain size ranging from 20 to 3 grains/in.^{2} at 100X have no detectable effect on the temperature of the start of the Ar″ transformation in this alloy.

Other Factors

Earlier studies of round bars had sug-



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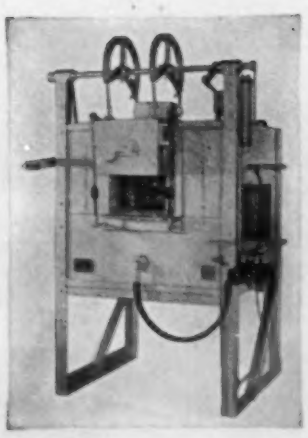

Hundreds of special tools vital to defense work —like the above airplane broaches—are daily being placed in "Certain Curtain" furnaces. To have to re-make them because of spoilage, would involve serious delay and expense. To develop less than maximum working life in the steel would mean loss of badly needed production.

To the heat-treating of modern tool steels, "Certain Curtain" patented control of furnace atmosphere brings CERTAINTY: certainty that tools and dies will not have to be re-made; certainty that MAXIMUM working life can be developed by adequate heating under precision atmosphere control. Bulletin A-102 upon request.

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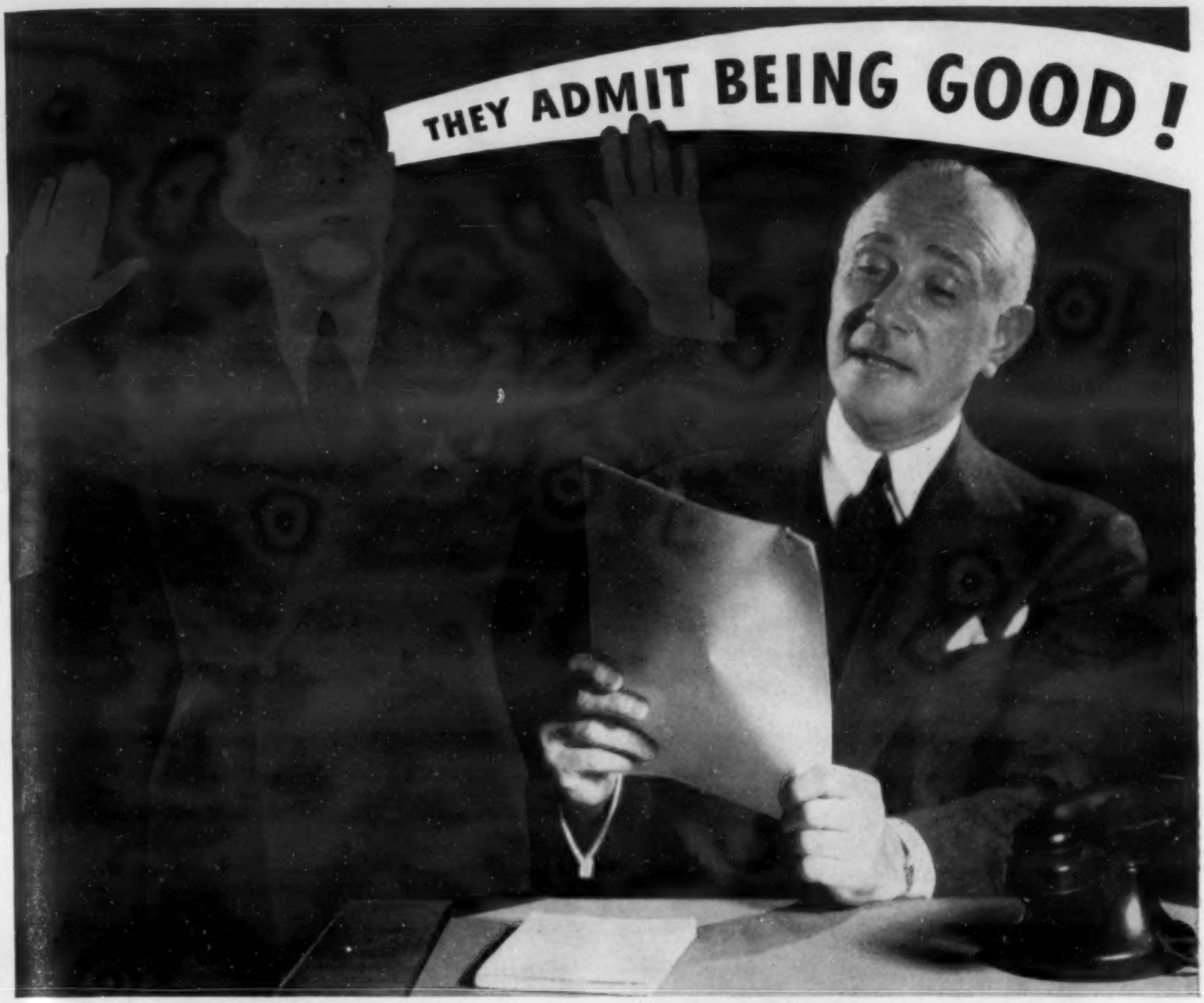

ALTER EGO: Literally "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

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Well, here's the third different welding rod proposition that lays eloquent emphasis on the claim that it's as good as "Fleetweld." *That's stimulating.*

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That prompts me to ask myself—"Why is 'Fleetweld' taken as the standard of welding electrode comparison?"

ALTER EGO: Maybe Lincoln can give us the FACTS and we can judge for ourselves.

• •

LINCOLN SUGGESTS: To find out why "Fleetweld" is the standard of comparison for welding quality and economy, TRY IT! Compare it to other electrodes. In what ways? See the 30-Point Check Chart on Page 5 of the New "Weldirectory." This 56-page procedure guide (gratis) gives all the FACTS about 37 Lincoln Electrodes for welding and hard-surfacing—where to use them—how to use them—what weld properties to expect.

LINCOLN "SHIELD-ARC" WELDING
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gested to M. ASIMOW & M. A. GROSSMAN of Carnegie-Illinois Steel Corp. a method for judging severity of quench as well as a criterion of hardenability. The method is based on the concept of "critical size", or the bar diameter that is just "hardened throughout" as seen in an etch test, as applied with reference to the severity of quench.

These authors now apply these principles to shapes other than rounds ("Hardening Characteristics of Various Shapes", *Ibid.*, 30 pp.). For flat plates, a set of charts is developed, which is entirely analogous to those previously calculated for rounds, and is found to accord closely with experimental data. For irregular shapes not subject to precise calculation, an approximation is suggested, in which each point in the irregular shape is considered to behave like a corresponding point in a round bar of "equivalent diameter".

Constant-temperature transformation is increasing in importance, not only as the basis of commercial heat treatments of the "austempering" type, but for determining the hardening behavior of steels. R. A. GRANGE & J. M. KIEFER of United States Steel Corp. ("Transformation of Austenite on Continuous Cooling and its Relation to Transformation at Constant Temperature", *Ibid.*, 30 pp.) attempt to find a simple relationship between the conventional transformation (on cooling) and the isothermal process, using a nickel-chromium molybdenum (S.A.E. 4340) steel.

The transformation occurs over a temperature range in which transformation at any instant during the cooling corresponds to isothermal transformation at the same temperature. Cooling transformation is, therefore, related to isothermal transformation. A cooling transformation diagram analogous to the isothermal diagram can be derived from isothermal data or determined experimentally. It lies below and to the right of the corresponding isothermal diagram.

The derived relationship between transformation on cooling and isothermal transformation may be advantageously employed in actual heat treatments provided the cooling history is known. It may also be used for determining the rate of cooling necessary to achieve a desired final product and combination of mechanical properties. Conversely, the transformation that occurs during hardening, welding or heat treating by any method of controlled cooling can be predicted from the isothermal diagram, which aids in understanding and designing such thermal changes.

Constant-temperature transformations are used by J. R. BLANCHARD, R. M. PARKE & A. J. HERZIG of Climax Molybdenum Co. ("The Effect of Molybdenum on the Isothermal, Subcritical Transformation of Austenite in Low and Medium Carbon Steels", *Ibid.*, 19 pp.) to study the effect of molybdenum on austenite decomposition. S-curves were constructed for steels ranging between 0.11% and 0.45% C and 0.15% and 0.75% Mo.

The effectiveness of molybdenum in promoting the hardenability of steel is demonstrated. In addition, the distortions that molybdenum produces in the S-curves prepared from isothermal data indicate that the complete description of the influence of molybdenum on the decomposition of austenite is complex. EF (2a)

Short-Cycle Malleableizing

"SHORT CYCLE ANNEALING." R. M. CHERRY (Gen. Elec. Co.) *Iron Age*, Vol. 146, Sept. 26, 1940, pp. 34-37. Practical.

The time cycle for annealing malleable iron can be decreased by : (1) Change in the analysis of the iron (usually by increasing its silicon content); (2) use of a protective gas atmosphere in the heating chamber (thus saving time ordinarily consumed in heating-up solid packing material); (3) loading castings in smaller baskets; (4) using modern furnace equipment that gives uniform temperature distribution. In one case, the old cycle of 8-9 days has been reduced to 36 hrs., and in another a 168-hr. cycle was reduced to about 15 hrs. The short-cycle anneal is used not only for shorter time but also to obtain operating economies.

By using an electric furnace, the heat can be located where desired and in the amount desired, giving accurate temperature control; temperatures in electric furnace heating remain constant. Where production warrants a continuous furnace, those of the roller hearth or pusher tray types are recommended. For smaller production, a batch type furnace of the "elevator" type is used.

For large production that warrants the continuous type of furnace, the question is to select the proper size of roller hearth or pusher tray furnace. In the roller hearth furnaces, the trays are moved continuously by a driven roll table. In pusher tray furnaces, the loaded trays are moved intermittently one tray length at a time. The roller hearth has certain advantages over the pusher tray furnace; the first cost of the roller hearth is higher, but this is partly offset by its lower firing cost.

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FOR EXTREME WEAR RESISTANCE AND TOUGHNESS

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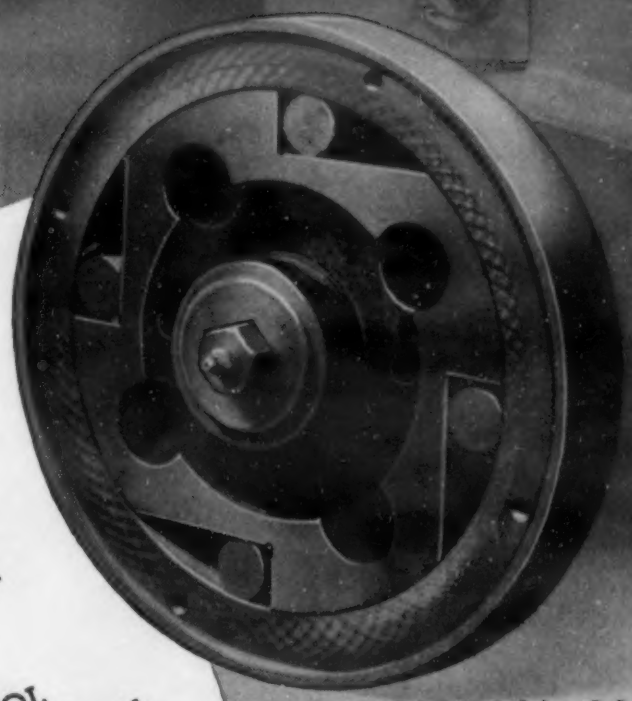
PRODUCTION MEN, MASTER MECHANICS and ENGINEERS are today concerned with maintaining machines straining under unequalled production demands. On critical parts requiring too frequent replacements, many are turning to some of the newer tool and die steels on applications formerly served by alloy steels. Many such interesting examples concern Crucible's AIRKOOL.

Thousands of Tool and Die Makers know AIRKOOL as the unusually tough steel that's readily machinable with minimum distortion and unusual wearing properties. Outstanding too, is its simple air hardening treatment. Now these same properties are being profitably applied by PRODUCTION MEN, MASTER MECHANICS and ENGINEERS for important machine parts.

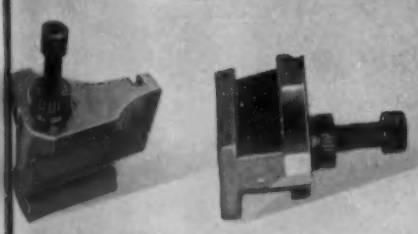
Pictured here are two such examples where AIRKOOL'S properties fit the all-around requirements of the job better than high quality alloy steels. Among other typical applications are lathe centers, indexing cams and medium-stressed spindles where wear resistance is the primary factor.

With down-time doubly dangerous today, check your maintenance department and discover what parts are being requisitioned for constant replacements. The result may surprise you! Then call our nearby representative to discuss AIRKOOL'S possibilities on each job. Free folder TS 201 on request.



AIRKOOL CAM

$5\frac{7}{32}$" diameter, $1\frac{1}{4}$" thick, weight 6 lbs. The service requirements are extreme resistance to wear and toughness. Too, this part with thick and thin sections was difficult to harden. Complications with previously used Alloy Steels were solved with AIRKOOL.



COLLAPSIBLE TAP BODY OF AIRKOOL

10½" diameter, 8" thick, weight 25 lbs. AIRKOOL chosen because it gave greater wear resistance on the bearing surfaces. Size changes an distortion was less than .001", and 80% improvement over the case carburized steel formerly used, effecting remarkable savings in costly grinding and lapping.

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In one continuous roller hearth furnace described, the chamber proper is never opened to outside air. The furnace is divided into 4 sections along its length: (1) A high-temperature zone, where castings are heated to about 1750° F., and held the required number of hours; (2) a fast-cooling section; (3) the holding or slow-cooling section; and (4) a final, fast-cooling section, in which cooling is done by means of water tubes located in the top of the furnace. The high temperature section is heated by ribbon resistors mounted in the top and bottom of the furnace. The protective atmosphere is provided by a gas converter of the combustion type for processing city gas, natural gas or any of the tank gases.

Where flexibility is desired, batch furnaces should be considered. In the electric elevator type, with one or more chambers built into a shell, the charge is loaded on a car and the load elevated into the heating chamber. In a single chamber, the charge after completion of the high-temperature portion of the cycle is removed and allowed to cool outside to the lower temperature required for graphitizing, and then replaced in the furnace. Multiple chamber furnaces are preferred, to eliminate heat losses.

VSP (2a)

Extruding Valves

"Extrusion Process of Valve Production." *Machinery, London,* Vol. 56, July 4, 1940, pp. 437-440. Practical.

Hand forging of valves is used only when a small quantity are to be produced or when a high quality material difficult to work is used. The process is slow and involves considerable work. In hand forging, the part of the bar intended for the head is left untouched, while the stem part is drawn out to the correct size.

Electrical upsetting is especially used for inlet valves. The end of the bar is heated with a resistance heater, then upset to the correct head size. A high output can be obtained with semi-skilled labor, but the operation is very severe, particularly with larger valves. This process is not used in England for heat resisting steels.

The Doncaster extrusion process employs roughing and finishing dies, located side by side. The slug is heated, inserted in a sleeve die, then forced through the taper die. Although the steel is thoroughly worked, this method is not as severe as the upsetting method. Furthermore, a very desirable grain flow perpendicular to the working face results. JZB (2a)

Reconditioning Still Tubes

"Annealing Furnace Permits Re-Use of Still Tubes." *Refiner,* Vol. 19, Aug. 1940, pp. 280-281; *Library Bull. Abstracts,* Universal Oil Products Co., Vol. 15, Aug. 24, 1940, p. 134. Practical.

Cracking still tubes are being reconditioned by cutting off the ends damaged by corrosion and erosion, welding on new ends and annealing.

The tubes are inspected thoroughly when they are removed from the furnace, and those with thin walls throughout most of the length are discarded. Tubes damaged only at the header roll are shortened about 2 ft. by a cut made in the form of a U bevel. Other shorter tubes are cut in 2-ft. sections, one end square and the other with the U bevel for welding. The welding is done with an electric torch and rods of low-chromium, ½% Mo steel.

For heat-treating the re-lengthened tubes, the annealing oven consists of a fire-brick combustion chamber 6 ft. wide and 15 ft. long with a steel superstructure that holds 16 tubes at a time. Tube supports at intervals between the 3 burners prevent the tubes from being malformed during the heat. Three thermocouples on the side of the oven opposite the burners are connected with a recording instrument so that the progress of the annealing may be controlled.

After the tubes have been placed in the oven, all openings in the superstructure and tube ends are closed with plastic insulation, and the long ends extending from the end of the furnace are covered with split magnesia insulation to avoid an abrupt change of tube temperature from the inside of the oven to the outside. (2a)

Lining Vessels with Stainless

"Surface Cladding." George E. Gude, Jr. (Wyatt Metal & Boiler Works) *Steel,* Vol. 107, Aug. 26, 1940, pp. 44, 46. Descriptive.

In a new method of surface cladding processing vessels, corrosion-resisting lining material is applied in strips 4-6 in. wide and 3 ft. or more long. The space between each strip permits one bead of high-alloy welding rod to be laid in between, thus joining the two parallel edges and simultaneously welding both edges to the carbon steel plate. No intermediate welding by plugs or strips is necessary, and a smooth-appearing surface with a minimum amount of welding results.

Manhole necks and large nozzles are lined similarly. Flange faces are coated with corrosion-resisting steel welding metal applied in three layers, subsequently machined.

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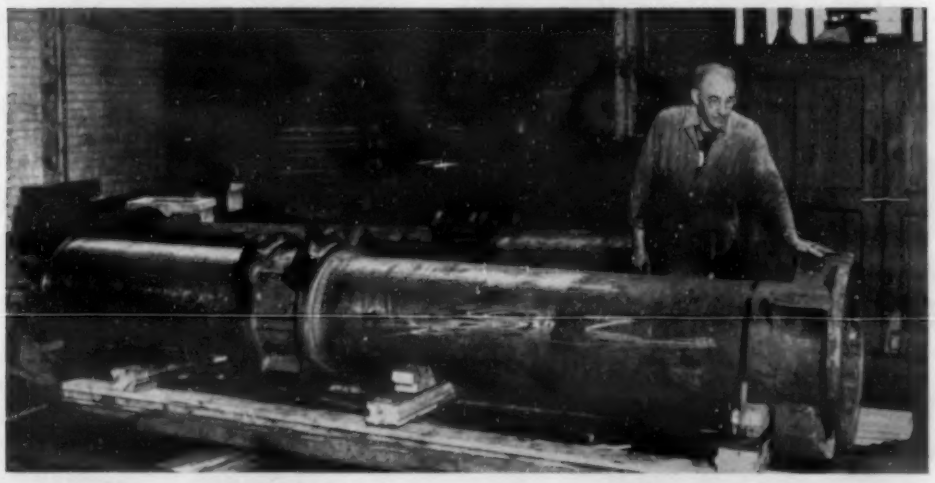
SOUND CASTINGS



The photograph shows a Duraloy Nickel-Chrome Retort with 1" wall being used for heat-treating purposes in a large nut and bolt factory in the east. Here are its advantages:

1—4 years' life (and still going) as against 6 months' life for formerly used steel retort 4 inches thick.
2—time out for and costs of changing greatly reduced.
3—elimination of retort scale from pickling tank which periodically had to be shovelled out.
4—time for heating up decreased.
5—required changes in temperature quickly achieved because of relatively thin wall.

We can think of no better example of what a properly-made high alloy casting of the proper analysis can do to reduce processing costs.

Duraloy has the reputation and record of turning out sound chrome-iron and chrome-nickel castings. We have been at it since 1922.

Since 1931, also a pioneering date, we have been making centrifugal castings which for many purposes are greatly to be preferred.

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Smaller openings are lined with corrosion-resisting steel tubing, welded to the flange with a continuous bead around the periphery at the inside of the nozzle. Manhole and nozzle liners are welded to the inside lining of the vessel where the linings meet. The vessels must be stress-relieved after lining.

Ordinarily the cladding is 12-16 gage stabilized stainless steel. To overcome the loss of alloying elements when fusing the lining to carbon steel plate, 25-12 stainless or a similar welding rod is used on 18-8; a rod of higher alloy content is used in welding other alloys. The rods are usually 5/32 in. diam., and a potential of 23-26 v. at the arc with current of 80-134 amps. are used. The small rod is used to eliminate excessive heat in welding, which might result in distortion of the lining.

The carbon steel plate is first prepared by sand blasting and all edges of the lining sheets are sheared square. Then the sheets are laid in place and tack welded to the carbon steel. One pass of the alloy welding rod completes the joint. All joints are tested by placing a vacuum chamber over the welded portion of the lining after the application of soap suds. MS (2a)

Pickling Inhibitors

"Data on the Use of Stannous Chloride as a Pickling Inhibitor." T. P. Hoar & S. Baier. *Sheet Metal Inds.*, Vol. 14, Sept. 1940, pp. 947-948. Research.

Stannous chloride in conjunction with flour has been found to reduce hydrogen absorption in steel during pickling as well as to decrease metal loss. Some figures for metal loss of black plate (loss is in mg., in 10 min., from the surface of 3 in. x 3 in. specimens) in fresh solutions are:

Bath	Metal Loss, mg.
7% by weight H_2SO_4 at 175° F.	43.0
Same with 0.1% flour	10.1
Same with 0.1% $SnCl_2 . 2H_2O$	8.3
Same with 0.1% flour plus 0.1% $SnCl_2 . 2H_2O$	3.9
Same with recommended additions of 3 commercial inhibitors	3.6-3.2
Same with 0.5% $SnCl_2 . 2H_2O$ plus 0.25% gelatine plus 0.05% cresolsulphonic acid	3.2

Weight for weight of inhibitor, the stannous chloride is not so effective an inhibitor as the commercial inhibitors. As the acid was used up so was the inhibitor; however, every bath remained sufficiently inhibited until it was spent. Gelatine (0.05%) is more advantageous than 0.1% flour for use with stannous chloride, as it has better solubility, superior inhibiting power and gives a cleaner liquor. The cresolsulphonic acid has no inhibiting influence, but prevents the oxidation of the stannous chloride, which had caused difficulty in former tests.

If stannous chloride is used in conjunction with one of the commercial inhibitors, metal loss is still further reduced. The recommended bath is the last in the above table. JZB (2a)

2b. Non-Ferrous

Soldering Aluminum

"Aluminum Soldering. A Review of the Literature to July 1, 1939." W. Spraragen & G. E. Claussen. *Welding J., N. Y.*, Vol. 19, Sept. 1940, pp. 313s-322s. Correlated abstract.

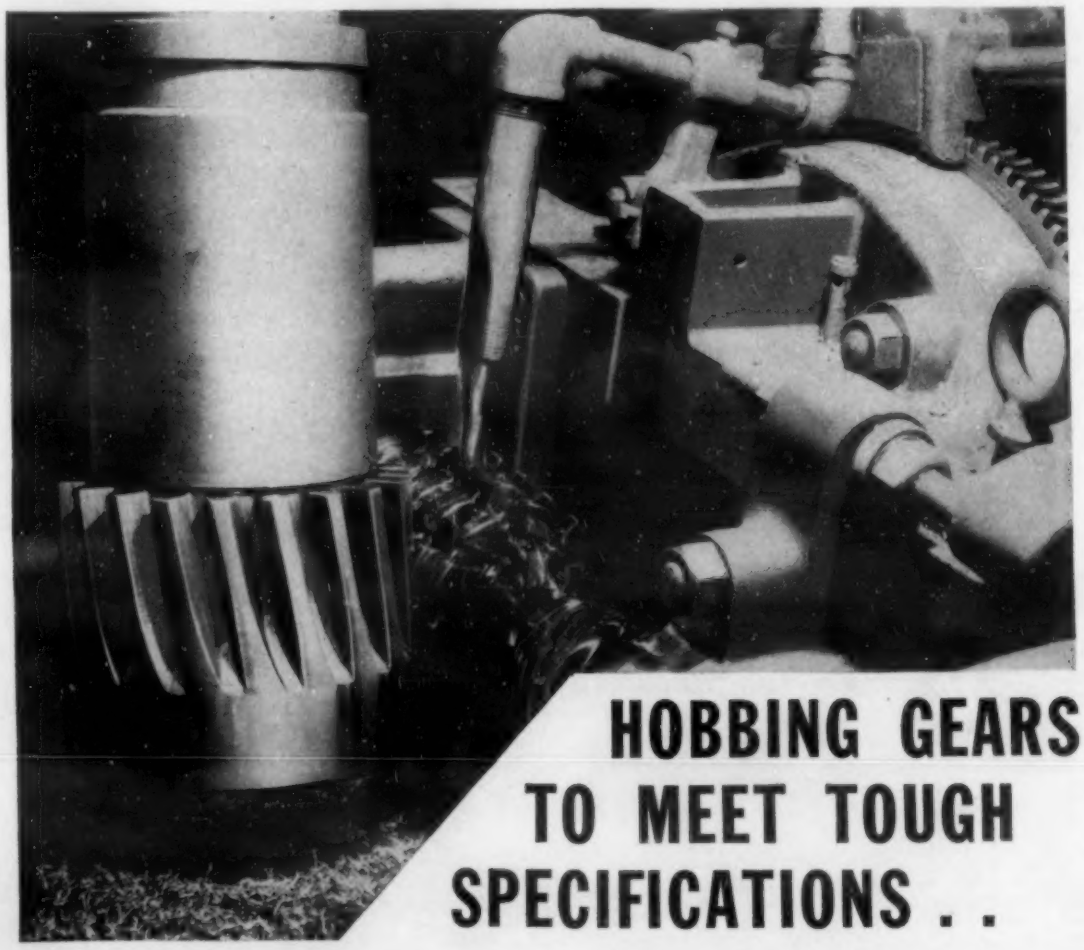
Flux and friction solders are of many compositions—it is safe to say that a thousand separate compositions and ranges of compositions have been patented or recommended.

The zinc content of most solders for aluminum is their distinguishing feature. Zinc solders often are of the pasty type and exhibit good intergranular penetration. Zinc is said greatly to facilitate the wetting of aluminum by tin-rich solders, although one investigator stated that tin has better wetting properties than zinc. Cadmium may be particularly suitable for friction soldering and imparts corrosion resistance to high-zinc solders. Phosphorus, copper, iron, silver, lithium and vanadium additions have each been used.

Solders melting at 355° F. have given satisfaction, although 400°-575° F. seems to be better. With most aluminum soldering, indirect or torch heating is preferable to a soldering bit, which is said to be limited in application to foil or wire up to 0.004 or 0.020 in. thick, because of the oxide film and the high thermal conductivity of aluminum.

In friction soldering the solder is allowed to melt on the preheated part to be "tinned". The aluminum surface is scratched under the layer of solder by means of a soldering bit, wire brush or scraper. Rubbing seems to permit tinning to occur. The aluminum must be preheated to facilitate removal of the oxide film (because the aluminum is in a soft condition) and to favor intermetallic reactions, and soldering temperatures of 575°-850° F. should be used. Flux is sometimes used in addition to rubbing.

The first step in flux soldering usually



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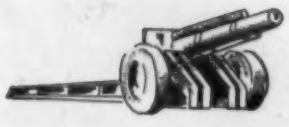

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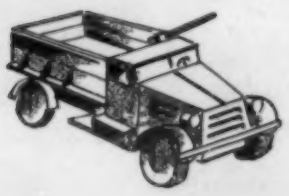

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involves etching the surface with dilute phosphoric acid, hydrofluoric acid, or 25% nitric acid plus a little hydrofluoric acid. The part is then tinned with the same solder as for friction soldering (high-zinc; 64 Sn, 36 Pb; or tin-lead-bismuth eutectic), the necessary temperature being 400°-850° F. Etching is not essential, however; it is sufficient to melt an alkali halide flux on the surface with the molten solder, and during heating the solder is observed suddenly to spread over the fluxed parts. On the other hand, after etching a flux need not be used, or a flux such as stearine, designed only to exclude air, may be adequate.

If a large defect in a casting is to be filled, the surfaces are tinned with friction solder after which wiping solder is molded into the cavity. The wiping solder is conveyed to the defect in a pasty condition (480°-660° F.). No flux is required but the casting must be preheated if the solder is to adhere.

Reaction solders are mixtures of chlorides of heavy metals, such as tin, zinc, lead and cadmium, which are spread on the part to be tinned or soldered. Upon heating the part, the salts react to form aluminum chloride and the heavy metal or metals. The oxide film is removed by the reaction and the heavy metals alloy with and tin the aluminum. Reaction solder is applied particularly to stranded aluminum cables, which do not require so careful preparation as in ordinary friction soldering.

With respect to corrosion of soldered joints in aluminum, moist air or boiling water swiftly corrode soldered aluminum. Tin-lead solders are cathodic to aluminum and therefore decrease the corrosion resistance in 0.1 *N* NaCl far less than anodic solders, which contain 8-75% zinc. Blisters are likely to form in tinned surfaces in water, owing to hydrogen evolution.

As to the "metallurgical" aspects—two actions are chiefly involved in aluminum soldering, (a) penetration of the solder through cracks in the oxide film or the aluminum, and (b) spreading of the solder over the surface of the aluminum. The ability of a molten metal to penetrate cracks is increased by lowering the surface tension, which, in general, is lower at a given temperature for metals of low melting point than for metals of high melting point. The spreading of solder over the surface depends on "spreading power," about which there is no quantitative information at present. The diffusion of the solder into aluminum during heat treatment may occur uniformly or preferentially along the grain boundaries.

Aluminum alloys, such as duralumin, are soldered in the same way as aluminum itself. Even with solders of the lowest melting point, the duralumin is softened to about the same extent as in welding. Aside from the soldering of aluminum to copper conductors and an occasional special application, such as soldering steel and brass fittings to 13% Si aluminum alloy boxes, there are few occasions for soldering aluminum to other metals.

Investigations on the reactions and behavior of the oxide film on aluminum during soldering are strongly urged. Tests are also required to enlarge the possible range of conditions under which soldered joints may be used without fear of serious corrosion, and more information is required on the effectiveness of different methods of protecting the soldered joint from corrosion. The penetration of molten solders into aluminum should be studied. Finally, the rate of the reactions between some flux constituents and the aluminum metal at different temperatures should be studied, as well as the propagation of the reaction at an oxide-aluminum interface. WB (2b)

Anodizing for Abrasion Resistance

"The Abrasion Resistance of Anodically Oxidized Coatings on Aluminum." H. G. Arlt (Bell Telephone Labs.) *Preprint, Am. Soc. Testing Mat'ls.*, June 1940, 19 pp. Part of a symposium on anodic oxidation.

The development of an accurate air-blast abrasion testing apparatus and technique is described, and results on various anodic coatings reported. This test is suitable for the determination of the abrasion resistance of oxide coatings on aluminum and of other organic and inorganic coatings.

The test equipment consists of a calibrated glass nozzle in which the abrasive is mixed with compressed air and which is housed in a suitable container arranged for the easy insertion and observation of the specimens under test. Information is provided as to the necessary control apparatus to insure a uniform supply of low pressure air at closely controlled pressure and rate of flow. Data on several sets of anodically oxidized coatings showed a maximum variation between readings on the same test specimen of 18% for earlier data and 7.3% for later data.

Abrasion resistance increased with coating thickness. Unsealed coatings showed better abrasion resistance than either chromate or water-sealed, the water-sealed coatings having the lowest abrasion resistance at any thickness level. When the abrasion values are plotted against oxidizing time, it appears that the abrasion resistance approaches a maximum for the processing conditions employed. There are some indications that the unsealed coating drops off in abrasion resistance after a critical oxidizing time has been passed. This is also reflected in the thickness values. VVK (2b)

Plating Zinc Die Castings

"The Plating and Heating of Zinc Base Die Castings." F. F. Oplinger. *Proc. Am. Electroplaters' Soc.*, 1940; Preprint, 7 pp. Descriptive.

The plated coatings on zinc alloy die castings are subject to blistering, especially when heated to about 300°-350° F. for baking lacquer coatings. Certain procedures and precautions will aid in preventing blistering.

The casting should be plated very soon after polishing to prevent formation of tarnish on the surface. Solvent degreasing is used to remove buffing compounds and then followed by a mild alkaline cleaner. The solvent should not attack or discolor the surface of the casting. Cathodic cleaning requires 0.5-2.0 min. in a cleaner containing about 2.0 oz. of tri-sodium phosphate + sodium carbonate per gal. or 10-20 sec. in a cleaner containing 6 oz./gal.

Anodic cleaning or simple immersion may also be used. For acid dip a solution containing 0.5-1.0% hydrochloric acid is used. Stronger acid solutions must be avoided. Acetic acid, 10-20%, can also be used, but is not yet employed commercially. A strike in a copper cyanide bath is recommended before plating in either the Rochelle or high speed copper bath.

When a casting has been properly cleaned and plated, no diffusion of copper into zinc (and therefore no blistering) takes place at 250° F. in 60 hrs. At 325° F. slight diffusion occurs in 2 hrs. and complete diffusion of a coating 0.0005 in. thick in 100-150 hrs. Diffusion takes place more readily when the casting has been subjected to alkaline cleaning and to pickling for too long a time. AB (2b)

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3 Properties and Applications

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Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Aircraft Materials— Design, Fabrication and Testing

"Modern Aircraft Materials and Their Testing." K. R. Jackman (Consolidated Aircraft Corp.) *S.A.E. Journal*, Vol. 47, Nov. 1940, pp. 461-473, 496. Descriptive survey.

The choice of a new aircraft material or new uses for a standard material is usually a compromise among good strength-weight characteristics, ready availability in standard shapes, low initial cost, simplicity of fabrication, and low maintenance costs. Recent developments in the aircraft-materials field have involved not only the accession to favor of new materials, but new fabrication-uses of standard materials, and advancement in strain-gages and strain-measurement technique for testing aircraft materials.

Aircraft Materials

In the Table are presented the properties of aircraft metals and alloys that influence their selection by the metallurgical designer.

Aluminum and its alloys are still the most important type of structural material used in modern aircraft. Wrought alloys have been favored, but with better manufacturing control, X-ray inspection and designs controlled by castings-destruction tests demanding a 100% margin of safety, the use of castings is on the increase. Quantity considerations usually dictate the choice of sand castings; the heat-treatable alloy, 195 with about 4% Cu, has good strength, shock resistance and machinability. Casting alloy 220-T4 has the best combination of tensile properties and shock resistance of all the aluminum casting alloys.

Magnesium alloys, which provide excellent strength-weight ratio and good fabricating properties, are now used mainly for secondary structures such as seat brackets, conduit boxes, floor supports, etc. Their extended use into the structural field will depend on their present service record. Surface protection by chromating or chrome-pickling is essential for most components. An outstanding case of weight saving through magnesium alloys is the substitution of magnesium alloy castings for the more corrosion-resistant 195-T6 aluminum alloy in the wheels of large land planes.

Beryllium, as light as magnesium, hard as sapphire and with a modulus of elasticity 30% greater than steel, will probably continue to be unsuitable for structural purposes (as the pure metal) because of its lack of ductility. If, however, its price can be reduced from the present $30./lb. to something less than $6./lb., the use of beryllium metal as cast or hot-rolled sheet for aircraft armor plate might become feasible. The currently largest aircraft use for beryllium is as a constituent of the familiar copper-beryllium alloys.

Among the ferrous materials, the use of chromium-molybdenum steel (S.A.E. X4130) is widespread, with a nickel-chromium-molybdenum steel (S.A.E. 4345) challenging its position. S.A.E. 4345 steel sheet that has been welded and then heat

Properties and Cost of Aircraft Metals

Material					Cost (Approx.)			Tensile Properties						
		Spec. No.												
Type	Name	Army	Navy	Form	$/lb.	$/in.³	Specific Gravity	Ultimate ÷ 10^3	Yield ÷ 10^3	Elong. %	Mod. Elast'y. ÷ 10^6	Strength Weight Ratio	Shear Strength ÷ 10^3	Fatigue Limit ÷ 10^3
Aluminum Alloys	17ST	WW-T-786	44-T-21b	Tube	1.60		2.79	60	37	20	10.3	21.5	36	15
	24ST	11066	47-A-10	Sheet	.60	.06	2.77	68	44	19	10.3	24.6	41	18
	24ST-Alc	11067-II	47-A-8	Sheet	.60	.06	2.77	62	41	18	10.3	22.5	40	
	24SRT	11067-III	47-A-10	Sheet	.70	.07	2.77	70	55	13	10.3	25.3	42	
	25ST	57-153	46-A-7	Bar			2.79	55	30	16	10.3	19.7	35	15
	14ST	57-153	M-277B	Bar	1.00	.10	2.79	65	50	10	10.3	23.3	45	16
	195-T4		46Ale-4	Casting	1.35	.13	2.77	31	16	8.5	10.3	11.2	24	6
	356-T4		46Ale-3	Casting	1.35	.13	2.65	28	16	6	10.3	10.6	22	
	220-T4		M-186	Casting	1.35	.12	2.56	45	25	14	10.3	17.6	33	7
Magnesium Alloys	"M" Alloy	(AM3S)	M-314-11	Sheet	1.00	.04	1.76	35	27	9	6.5	19.9		6.5
	"E" Alloy			Sheet	1.20		1.79	45	34	9	6.5	25.2		
	"J" Alloy	(AM57S)	M-314b-8	Extrusion			1.80	43	30	17	6.5	24.0	20	17
	"H" Alloy	57-74-1C	M-112AL4	Casting	2.00	.13	1.83	38	18	5	6.5	20.8	18	10
Copper Alloys	Naval Brass	57-162	46-B-6	Bar	.30	.09	8.23	67	45	22	15	8.1		
	Aluminum Bronze	QQ-B-666	46-B-17b	Bar	.50	.14	7.8	75	37	20	15	9.6		
	Manganese Bronze	QQ-B-721	46-B-15c	Bar	.30	.08	7.8	85	60	5	16	10.9		
	Lumen #20			Bar	.60	.17	7.7	110	70	12	16	14.3		
	Cu-Be (H.T.)			Sheet	1.30	.39	8.23	175	134	6.3	18.9	21.2	95	
Alloy Steels	1025	57-107-9B	46-S-22	Bar			7.8	55	36	22	28	7.1		25
	2330	57-107-17b	46-S-21b	Bar	.15	.04	7.8	125	100	17	29	16.0		65
	X4130	57-107-19b	46-S-23E	Bar	.15	.04	7.8	150	135	18	29	19.2	100	78
	4345	11062	46-S-28	Sheet			7.8	230	220	4	30	29.5		95
Stainless Steels	18-8	57-136-9	47-S-19	Sheet	.70	.19	7.8	80	35	40	26	10.2	70	30
	18-8	11068	47S21½H	Sheet	.70	.19	7.8	150	110	10	26	19.1	100	55
	18-8	10079	46S18-1C	Bar	.55	.15	7.8	120	60	15	30	15.3		
	18-8	10079	46S18-7E	Bar	.55	.15	7.8	100	50	28	29	12.8		
	16-2		M-286	Bar	.50	.14	7.8	175	135	13	30	22.4		
Nickel Alloys	Inconel	57174	47Nla	Sheet			8.55	125	100	7	31.5	14.5		
	Monel			Sheet	.80	.26	8.9	100	90	8	25.5	11.2		
	"K" Monel (C)			Bar	.80	.25	8.6	160	120	20	25.5	18.5		
	Be-Nickel (HT & Rolled)			Bar			8.1	260	213	8	27	32.0		

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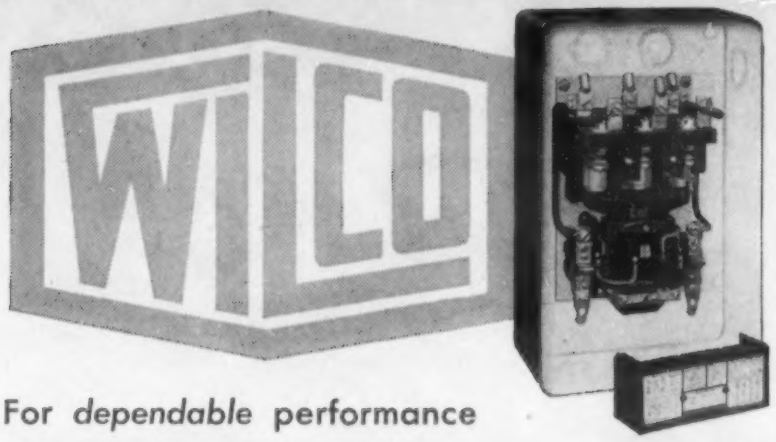

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treated to 230,000 lbs./in.^{2} can be machined almost as readily as X4130 with the conventional 125,000 lbs./in.^{2} heat treatment. The scaling of chrome-moly steel tubes and fittings during heat treatment can be overcome by the brushing-on of "Galvo", an anti-scaling compound available through the author's company.

Stainless steels of all types and in various forms are increasing in use, especially at the expense of chromium-molybdenum steel. Cold-rolled 18-8 (Navy 47S21) is widely used for structural purposes. Growing in use is the heat-treatable 16-2 stainless (Navy M-286) which can be quenched-and-tempered to 200,000 lbs./in.^{2} It is claimed that heat treatment to at least 175,000 lbs./in.^{2} is required to give M-286 bar stock its maximum corrosion resistance.

Plastic and wood-and-plastic construction probably will not immediately replace light metal construction. In the still-on-trial Duramold process, a wood-base material in large units is molded against wooden formers under heat and pressure, using plastic binders. The product is said to have 50% better fatigue strength than aluminum alloy, 5 times the damping capacity of a metal and better thermal properties than metals.

Pre-Stressing and Pre-Compressing

The desire to make use of the portion of the stress-strain curve of aluminum alloy beyond the proportional limit, and to cold-work the material to gain the desired proptities with sufficient elongation remaining to cover the uncertain effect of impact loads, has led to the growing use of pre-stretching and pre-compressing methods of cold working 24ST aluminum alloy.

The Consolidated flying boat model 31 is constructed of pre-stretched stiffeners, the strength of which has been increased in tension by 28% at yield and in compression by nearly 6% at failure. Consolidated's present production practice is to draw the various shapes from strip stock in the "SO" condition. The heat-treated and age-hardened material is then stretched to leave approximately 3½% permanent set. The ultimate elongation is lowered an amount equivalent to the amount of pre-stretching. The cold working of properly heat-treated aluminum alloy has no appreciable effect on its corrosion resistance.

From the practical standpoint, pre-stretching is more promising than pre-compression, although efforts are underway to develop a practical shop pre-compressing procedure for aluminum alloy stiffeners in long lengths. The pre-stretching of stiffeners to 3½% set might conveniently and more economically be done by the material manufacturer on extruded sections, as an adjunct to his customary straightening operation after heat treatment. This would result in lighter aircraft structures at little cost to the plane manufacturer.

Strain-Gages

No precision instrument is more used by the materials test engineer than the strain-gage. Such dual-point gages as the Riehle and Berry extensometers are nearly foolproof and can be read accurately to 0.0001 in. The present trend toward monocoque aircraft structures, however, has created a demand for a light compact strain-gage that can be used on one side of a flat or curved surface.

The Huggenberger tensometer is useful in this respect, but it is over-sensitive to vibrations, easily dislocated, and useless where sheet buckling occurs. More suitable are electric strain gages of the type developed by Ruge and deForest (available from Baldwin-Southwark Co.), which depend on the principle that the change of resistance of a wire is proportional to the change in cross-section caused indirectly by a change in length.

The "Celstrain" gages (Consolidated electric strain-gage) are of this type, and have the advantage of remote reading and vibration insensitivity. They allow electric-resistance-type strain-gages to be placed internally in wing structures and in otherwise inaccessible positions. Recording equipment permits an operator to read the strains at any one of 30 gage locations without leaving his post. Celstrain gages are said to cost much less than the other strain-gages now on the market, and, with the Baldwin-Southwark gage, to offer the advantages of full-scale testing at 1/10 the gage cost of former remote-recording extensometers. (3)

3a. Ferrous

Iron Castings for Glass Molds

"Glass Molds Present Many Problems." Robert M. Scafe. *Foundry*, Vol. 68, Aug. 1940, pp. 30-31, 103, 105; Sept. 1940, pp. 36, 101-103. Practical.

The utility of the mold, mold-making requirements, economic problems and the value of some of the alloys used are discussed. Depending on the glass-making methods and the style of ware, molds are either solid or split. The solid mold consists of mold body, valves and plungers. Split molds consist of body in 2, 3 or more parts, bottoms, baffle plates, neck rings and plungers, and are used for either pressed or blown ware.

Cast iron for glass molds should be resistant to deterioration at elevated temperatures, to corrosive effects, to wear and to heat-dissipating qualities. Plunger irons should be made of different material than the mold because chilled glass has greater abrasive effect on the plunger than it has on the mold. (Neck rings, also subject to intensified wear, are made of high speed steels.) Mold iron should be machined readily and be capable of taking a high finish.

If plain gray iron is not satisfactory, special or alloy irons may be used. The present tendency in glass molds is toward the use of small amounts of one or more alloys. Chromium between 0.30 and 1.0% in such irons is of value because it intensifies chilling characteristics of the iron and has a refining effect on the graphite and on the matrix. Nickel restrains chill and hardens the pearlitic matrix. As an alloying element in glass mold iron, nickel is beneficial in promoting machinability, density and freedom from porosity. When used to displace silicon, it contributes to growth resistance.

Molybdenum mildly increases the chill, and strongly refines the matrix and the graphite. The addition of molybdenum increases structural uniformity and is conducive to good density, low thermal expansion and high conductivity. In combination with nickel, chromium or copper, molybdenum seems to enhance resistance to elevated temperatures, and it decreases growth particularly if used in percentages between 0.75 and 1.00%. Molybdenum has been used in glass mold irons up to 1.00% alone, and in combination with about 0.30% Cr.

The use of vanadium in the iron is somewhat analogous to its use in steel. As little as 0.10% V decreases distortion and growth, but increases hardness and depth of chill. One of the popular combinations for glass molds is that of nickel and chromium added in proportions in which they neutralize each other in respect to chill. VSP (3a)

Boiler Corrosion

A Composite

The embrittlement of steam boilers, variously called caustic embrittlement, intercrystalline cracking, etc., is still a major industrial problem despite exhaustive research in recent years. These studies, however, have broadly clarified the manifold causes of such failures and have indicated what preventive measures may be successful in many cases.

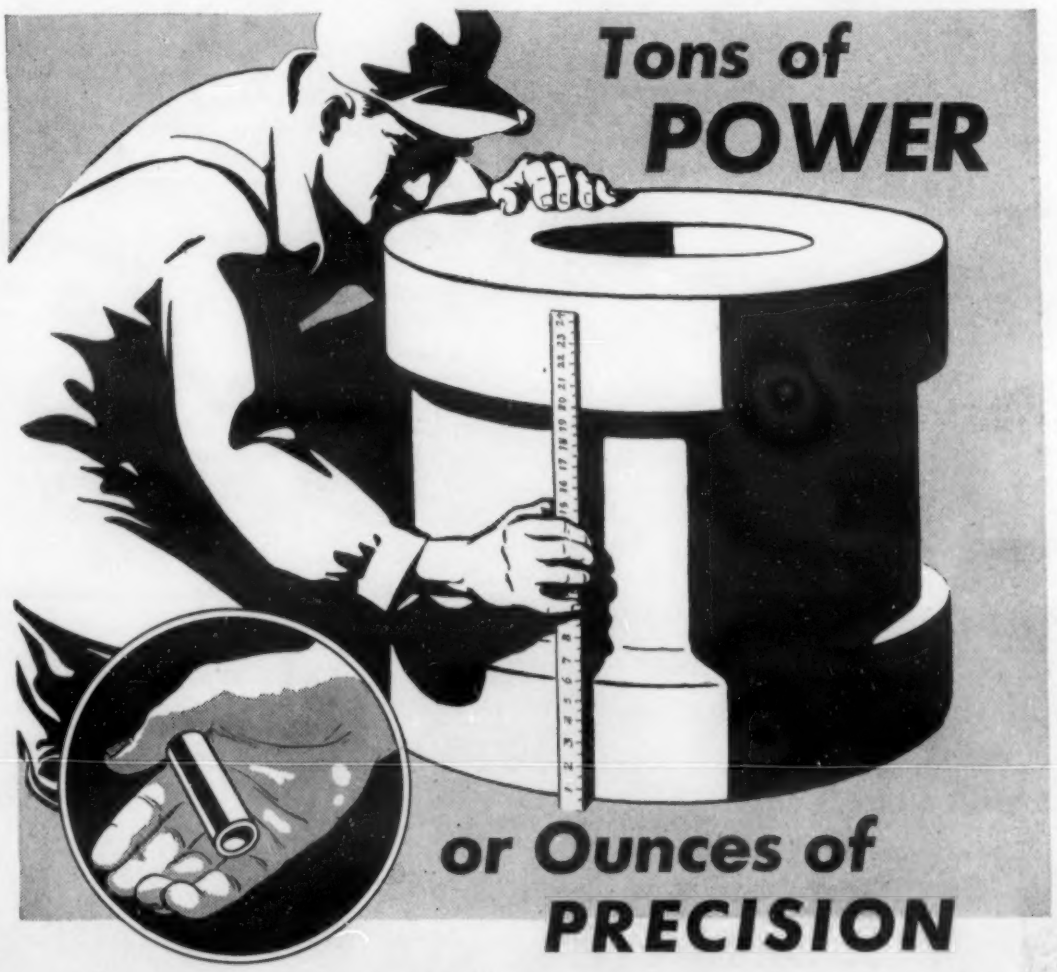
Treatment of boiler feedwater alone is not sufficient—boiler design must be such that cold work stresses are kept at a minimum and that the seams can be maintained "leak-free," states W. C. SCHROEDER ("Causes and Prevention of Embrittlement in Boilers," *Railway Mech. Engr.*, Vol. 114, May 1940, pp. 182-185). The addition of organic materials to the feedwater is apparently more helpful than the introduction of inorganic salts.

In another, closely related report W. C. SCHROEDER, A. A. BERK & R. A. O'BRIEN ("Intercrystalline Cracks in Locomotive Boilers," *Assn. Am. Railroads Circular*, No. D. V. 989, 1940; abstracted in *Railway Age*, Vol. 109, July 1, 1940, pp. 25-28) present a bird's-eye-view of the whole problem, and describe an embrittlement detector in which a very tiny leak is artificially produced, closely simulating the leaky-seam conditions that appear to give rise to embrittlement in service through concentration of impurities in the boiler water to a harmful level. It may be used in the laboratory to determine the susceptibility of a steel to embrittlement, to study the behavior of impurities in water or to evaluate the effect of inhibitors; or it may be installed on a locomotive in service to evaluate the waters with which the boiler is fed.

This report lacks the dogmatism of some of the earlier discussions, each of which claimed to have the one and only correct explanation. The metallurgical engineering high spot of the report is that by means of this detector, the lack of susceptibility of correctly made non-aging boiler steel of the Izett type (See METALS AND ALLOYS, Vol. 3, Mar. 1932, pp. 61-67) seems on the way to being established. It will be recalled that the German claims for the value of Izett were allegedly refuted some years ago and hence American attention was diverted from it. The latest work of Schroeder and co-workers so far corroborates the German claims.

In the description of the mechanism of cracking, the authors point out that the reaction $3\ Fe + 4\ H_2O = Fe_3O_4 + 4\ H_2$ produces the Fe_3O_4 within the crack and pries it open further by chisel action. [*No attention is paid to the disrupting effect of the hydrogen simultaneously produced, or to the possible role of hydrogen in any stage of embrittlement, a feature which, in view of present appreciation of hydrogen effects, certainly deserves consideration.*—H.W.G.]

The German claims for the superiority of non-aging steel are taken up again by G. T. ATHAVALE & W. EILENDER ("Beitrag zur Frage der Laugensprödigkeit von Kesselblechen," *Korrosion u. Metallschutz*,



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Vol. 16, Apr. 1940, pp. 127-132) in a study of the caustic embrittlement of boiler plate. They find that the resistance of mild steel to embrittlement depends unquestionably on the content of metallic aluminum, particularly in amounts above 0.05% Al. However, too much alumina (Al_2O_3) in the steel reduces the benefits obtained by the presence of aluminum.

Nitrogen content of the steel was found to be without effect on caustic embrittlement, and no direct connection between aging, grain size and nitrogen content and caustic embrittlement could be established.

Alloy steels are much more sensitive to caustic embrittlement than ordinary mild steel, according to tests made by M. ULRICH, K. WELLINGER & F. MÜLLER ("Laugenversuche mit unlegierten und legierten Stählen," *Mitt. Verein. Grosskesselbesitzer*, No. 74/75, 1940, pp. 274-280). With the different German brands of commercial superheated tube materials (plain carbon steel, molybdenum-copper steels and chromium-molybdenum steels) tested, variations in types and strength of alkalinity present, including the presence or absence of sodium silicate, were without much effect on the relative corrosion sensitivity of the various steels. X (3a)

3b. Non-Ferrous

Aluminum Alloy Bearings

ALUMINUM BEARING ALLOYS—REASONS FOR THEIR SLOW ACCEPTANCE ("Aluminium-Lagerlegierungen, Ursachen ihrer bisherigen geringen Verbreitung") E. VADERS. *Aluminium*, Vol. 22, May 1940, pp. 248-256. Practical review.

Bearings of aluminum alloys have not yet found the recognition the author thinks they deserve. Experiments have given good results, but the alloys have not been investigated systematically, and in many cases they have been used under the wrong conditions.

Aluminum bearing metals that have given good accounts of themselves, especially as piston alloys, contain larger amounts of iron or iron + copper or silicon + copper with small additions of magnesium—for example, the hypereutectic silicon-aluminum alloys with 14-22% Si. Aluminum-antimony alloys with 6-8% Sb have a hardness of 30-40 Brinell in the pressed or cast condition, and are satisfactorily shock-resistant.

Two new aluminum bearing alloys of interest are "Alva 36" and "Neomagnal A" of which the softer, Alva 36, is to be used in place of white metals while the hard Neomagnal A is intended to replace bronzes and special brasses. Alva 36 is an aluminum-manganese alloy with additions of lead and antimony or calcium. Its structure shows primarily precipitated aluminum-manganese surrounded by eutectic consisting of the α-aluminum-manganese solid solution + Al_7Mn and needle-shaped aluminum-antimony crystals, and emulsified lead. If the manganese is replaced by copper, aluminum-manganese is replaced by Al_2Cu.

The characteristic of Alva 36 is its combination of hard bearing crystals in the structure together with metallic additions like antimony, lead, etc. in amounts that enhance the bearing properties without impairing the resistance to high unit pressures. The content of antimony and lead is about 1-2%. The alloy is cast in sand molds or chill molds, and it can be rolled into sheets or pressed into rods. The sand cast tensile strength is 14,000-21,000 lbs./in.^{2} and Brinell hardness 30-50; pressed-and-drawn, the tensile strength is 36,000-43,000 lbs./in.^{2} and hardness 40-60 Brinell.

Alva 36 has a heat conductivity of 0.25 cal./cm. sec. °C. at 20° C., a thermal expansion coefficient between 20° and 150° C. of about 21.5 x 10^{-6} (slightly more than copper); specific gravity is 2.8, and shrinking coefficient 1.3-1.5%. Loads of 7,000-8,500 lbs./in.^{2} at 8 meters/sec. can be carried continuously. The satisfactory use of the alloy for automobile bearings is described.

Neomagnal A consists of aluminum, magnesium and zinc with equal parts of magnesium and zinc. Additions of manganese and silicon and sometimes lead are made. With about 5% magnesium and 5% zinc, $Al_2Mg_3Zn_3$ and Al_2Mg_3 are precipitated below 825° F. when cooling from the supersaturated ternary solid solution. The alloy for this reason has high hardenability, and can reach by heat treatment hardnesses up to 180 Brinell and tensile strengths to 85,000 lbs./in.^{2} The metal develops a very smooth and bright surface when machined, and its running properties are maintained up to 300° F. if the load does not exceed 3,000 lbs./in.^{2}

The alloy is used for bearings under varying directions of load, for replacing bronze cylinders or bushings, and particularly for the races of roller and ball bearings. It has also been successfully used for worm and spur gears in continuous operation under loads of 8,500 lbs./in.^{2} and speeds of 3 meters/sec. Ha (3b)

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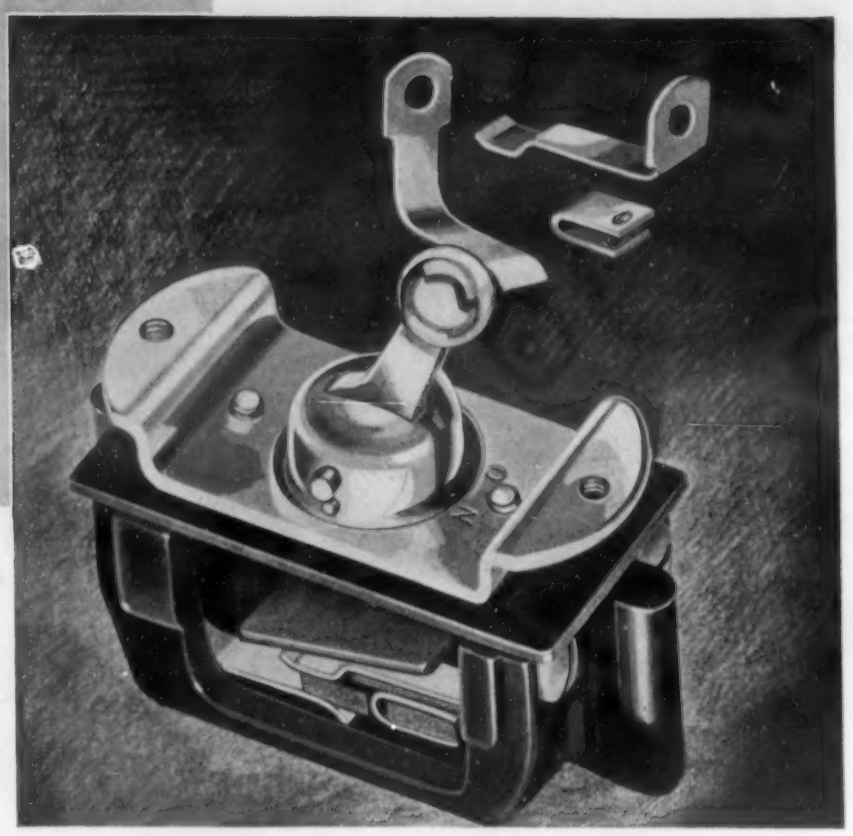

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Thermal Conductivity	.50 cal./sq.cm./cm./sec./deg. C	.50 cal./sq. cm./cm./sec./deg.C
Proportional Limit	80,000	50,000
Softening Temperature	500° C (932° F)	500° C (932° F)

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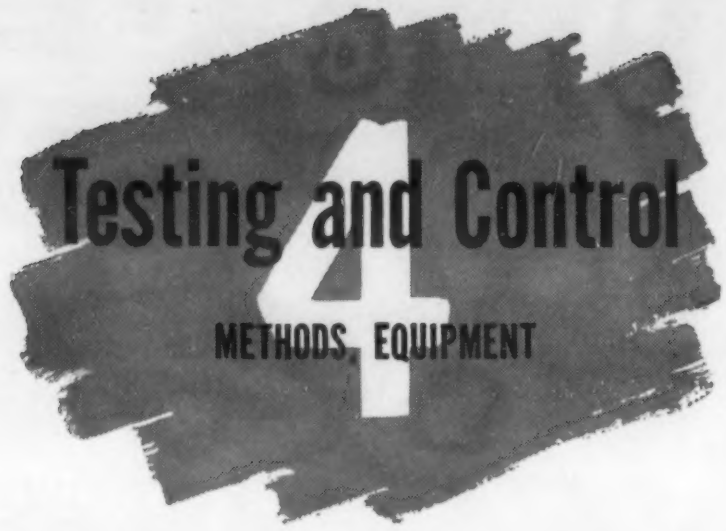

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Atmosphere Control Instruments

"Instruments for Control and Analysis of Controlled Atmospheres." E. E. Slowter & B. W. Gonser (Battelle Mem. Inst.) *Metal Progress*, Vol. 38, Oct. 1940, pp. 555-566, 569. Descriptive survey.

It is still practical to use the "hit and miss" system for "controlled atmosphere" installations where auxiliary equipment must be kept to a minimum, but apparatus for analyzing and controlling the atmosphere at all times is available to eliminate guesswork and assure proper conditions.

Direct measurements actually determine the effects of the atmosphere, while *indirect* methods measure some quality of the atmosphere that can be correlated with its direct effect on the work. Thus, the chemical composition of the atmosphere need not be known to control it, although such knowledge is really the basic measure of the effect of an atmosphere on the work, modern knowledge of atmosphere chemistry being what it is.

The principal basic methods for analyzing controlled atmospheres are (1) composition analysis by chemical means; (2) partial composition analysis by chemical means—either checking a component that bears a fixed relation to other components, or measuring the concentration of a solitary detrimental constituent; (3) determination of a physical property—gas density, thermal conductivity, or heating value—that is a direct function of chemical composition, and (4) direct trial of the atmosphere on the material being treated.

The large number and relative importance of constituents of controlled atmospheres—nitrogen, hydrogen, oxygen, carbon monoxide, carbon dioxide, methane, water vapor, hydrogen sulphide, etc. make a universal, automatic gas analyzer practically impossible. The best shop equipment, although manual, is the familiar Orsat analyzer; this can determine all constituents except water and hydrogen sulphide, which must be measured by separate instruments.

In a new oxygen recorder of Mine Safety Appliances Co., the oxidizing power of an atmosphere and therefore its oxygen content is measured by passing a CO_2-free sample of the gas over a rotating copper ring electrode; the copper oxide formed sets up a potential in an electrolyte through which the ring passes and the oxygen content is read directly from a suitably calibrated potentiometer.

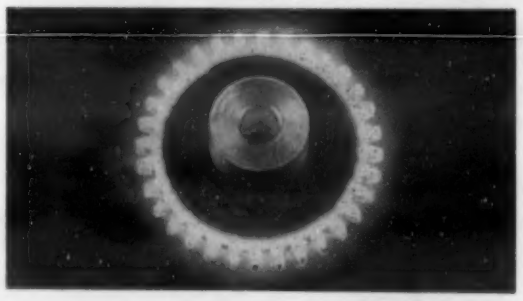
Composition changes in a standardized atmosphere may be noted by following changes in its specific gravity, as is done in the "Ranarex" indicators and recorders of Permutit Co. The density of the gas is measured by using it in a "fluid drive" and opposing its torque to that produced by atmospheric air.

Likewise, thermal conductivity changes may be used to indicate composition fluctuations, as in the Brown Instrument Co.'s "Analy-Graph" [fully described in an article by A. E. Krogh in our February and March 1937 issues]. This unit becomes an actual controller when its potentiometer is connected to the gas-producing unit so as to hold the atmosphere at any predetermined thermal conductivity.

Bacharach Industrial Inst. Co. makes a device that measures the heat of combustion (the gas must therefore be combustible) by mixing the unknown gas and air under standardized conditions and burning the mixture catalytically along an electrically heated platinum wire, whose electrical resistance will vary with the temperature to which it is raised by the gas combustion.

Other interesting equipment includes General Electric's portable dew point potentiometer for measuring water vapor content; Electric Furnace Co.'s visual gas tester, in which a strip of metal is heated electrically in a tube of flowing gas and its oxidizing nature is observed by tarnish or temper colors; Westinghouse's new device for direct indication through resistance measurements of the effect of an atmosphere on the carbon content of steels; and Continental Industrial Engineers' oxygen detector, in which a hot filament of copper alloy burns out quickly when the gas contains traces of free oxygen.

Rapid-acting, well-engineered recording and control equipment is thus available for determining specific properties of controlled atmospheres. No instrument is universally applicable—individual requirements must



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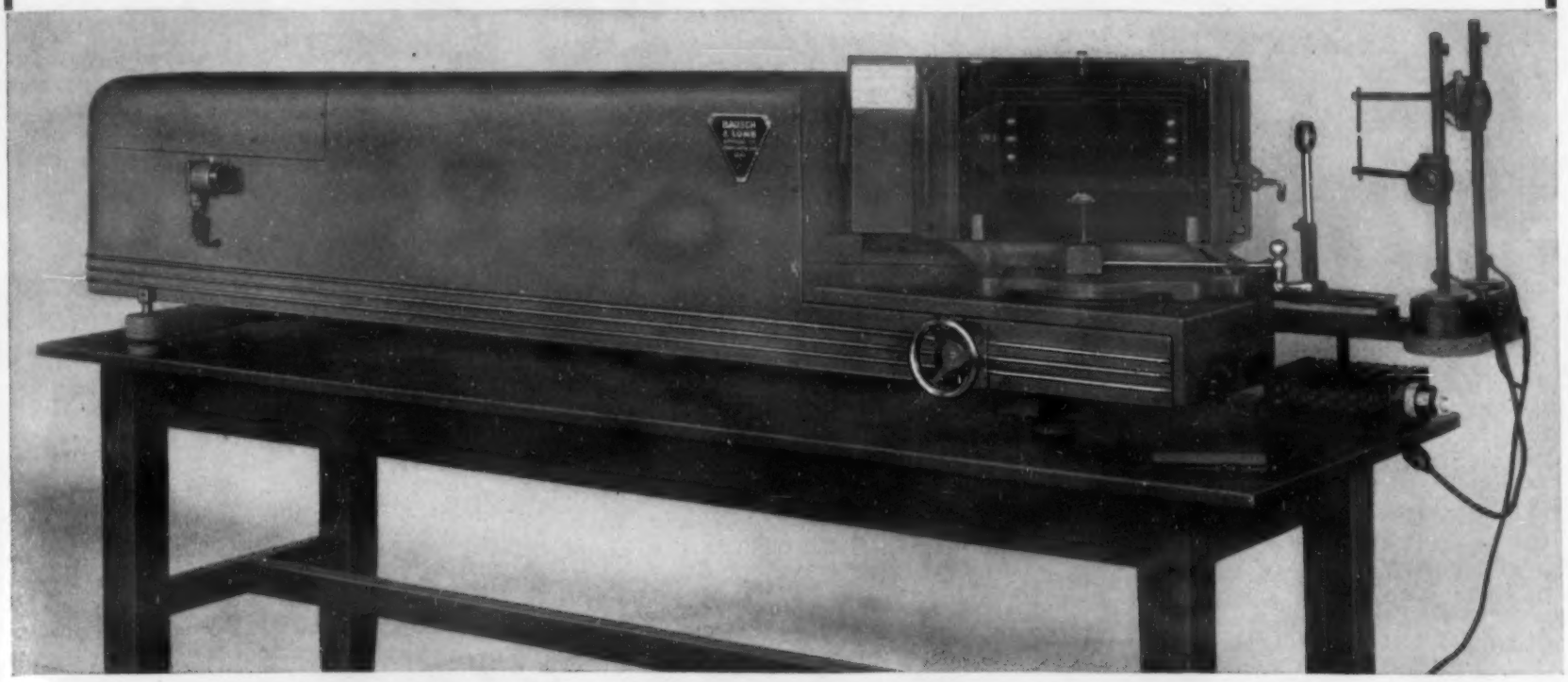

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be carefully determined, and chemical analyses are practically essential when new or unusual conditions are encountered.

There is a real need for a simplified and cheap device for special furnace atmosphere control—something that will provide the small or intermittent user with the type of atmosphere control that only large or continuous users of controlled atmospheres can now afford. FPP (4)

Inspection of Welded Units

"Fabrication, Inspection and Testing of Engine Entablatures and Welded Pressure Vessels." S. F. Dorey. *Eng. Inspection,* Summer 1940, pp. 23-29. Descriptive review.

The material most generally used for welded pressure vessels and similar fabricated units is a low carbon steel with tensile strength of 50,000-70,000 lbs./in.^{2}; sometimes steel with a minimum tensile strength of 68,000 lbs./in.^{2} or steel with 0.2-0.6% Mo is used. To meet the high requirements, it is necessary to use coated welding electrodes, and the deposit should have approximately the same composition and properties as the parent metal.

Inspection procedures are applied before manufacture, during manufacture, and after manufacture. Weld tests before manufacture will indicate the welding shop's methods and ability. Inspection during manufacture includes testing of the plates, examination of the plates after they have been assembled prior to welding, and observation of the welding with particular attention to the initial runs of weld metals, and cleaning of each run. Furthermore, the inspector must examine the X-ray photographs and witness the tests.

X-ray examination shows up porosity, cracks, and lack of penetration. Magnaflux tests may be important in the future. The inspector must also supervise the subsequent heat treatment of the vessel.

The tests required by Lloyd's are: all-well-metal tensile test, transverse tensile test, transverse bend test, impact test, and macrograph across the weld. Test plates are usually attached to the ends of longitudinal grooves in the shell and welded simultaneously with the seams, then stress-relieved or heat-treated with the vessel. Some criticism has been made concerning the inclusion of the impact and macrograph tests, but these are useful to demonstrate the consistency of the welds. The final test, naturally, is the application of the required hydraulic test to the completed vessel. JZB (4)

Tensile Testing

"An Investigation of the Effect of Rate of Strain on the Results of Tension Tests of Metals." Paul G. Jones & H. F. Moore (Univ. Illinois). *Preprint, Am. Soc. Testing Materials,* June 1940, 15 pp. Research.

Results of tension tests of 14 metals are reported using different speeds of testing. The apparatus used was autographic and employed a duplicate apparatus for weighing load—a compression block with carbon-pile compressometer and, in series with it, a steel tension weigh bar with an electric resistance extensometer. The stretch of specimen was measured by means of an electric resistance extensometer. Time records were made photographically on an oscillograph film by contacts fitted to an electric clock.

The results of the tests showed an appreciable effect of rate of strain on the tension test results, but, except for the stainless steel specimens, the amount of this variation might be expressed by the statement that a variation of rate of strain from N %/min. to 2N would introduce a variation not greater than 1% in the value of yield strength or tensile strength and not greater than 3% elongation or reduction of area, with the exception of elongation and reduction of area for the brittle cast metals tested. VVK (4)

Photoelasticity and Weld Design

"Cost and Procedure Control by Use of Polarized Light." E. W. P. Smith (Lincoln Elec. Co.) *Paper, Am. Welding Soc.,* Oct. 1940 meeting. Descriptive.

The peak or top stress is the governing factor in determining the load-carrying capacity of a structure. If the stress can be more uniformly distributed, more load may be safely carried and a reduction of "performance cost" obtained, or lighter sections may be used. Welded joints provide superior stress distribution as compared with other joining methods, but full advantage of their possibilities can be taken only when stress distribution is as uniform as possible.

To study stress distribution a number of methods are available, among them the use of suitable transparent models and polarized light. Direct study of a single model may be made or two joints may be placed on the same model and a comparison made. The joint showing high stress first (first to show color) is the first to be rejected; the model retained is modified, then compared with a third model, and so on until a satisfactory low-cost design is worked out.

In its elements the method consists of passing light through a polarizer (a prism

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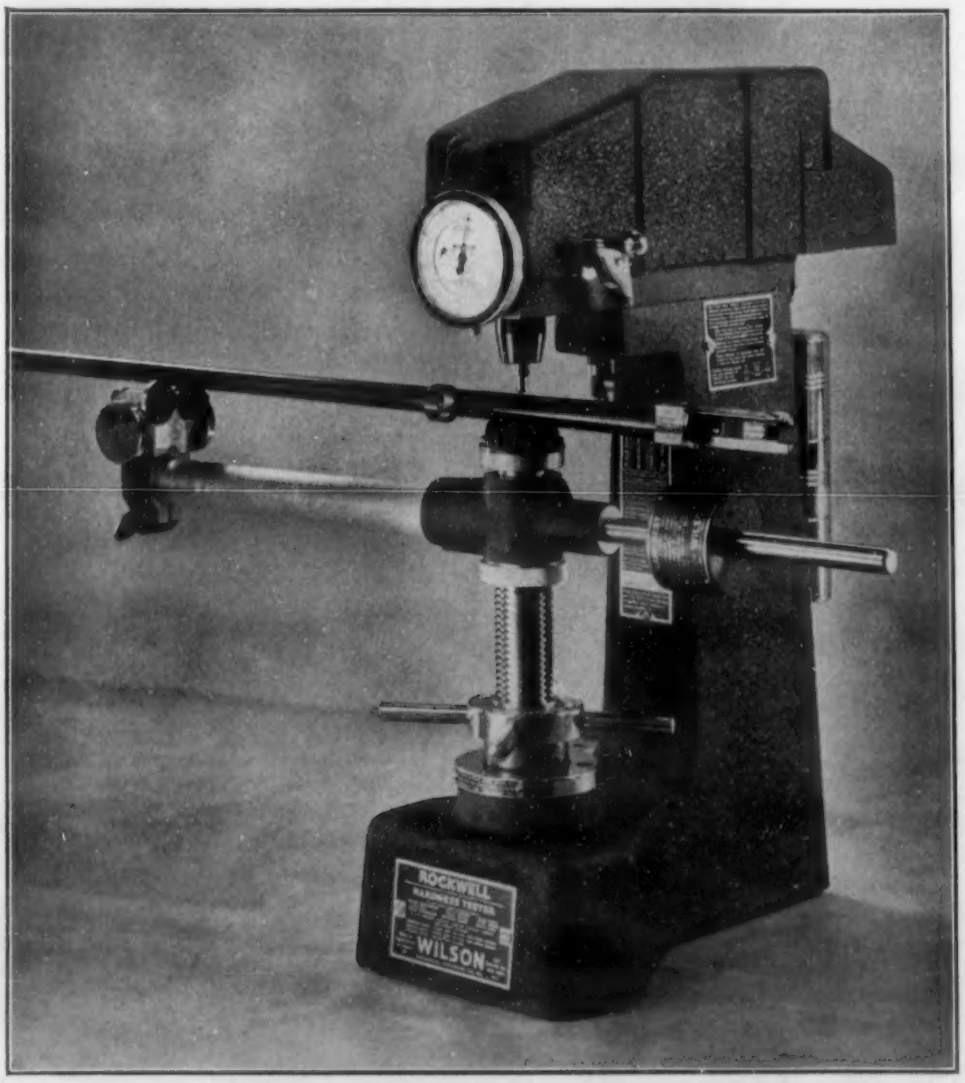

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IN the gamma-ray radiographic set-up, the film holders are placed on the metal face opposite to the radium. The castings can be placed entirely surrounding the radium, as well as above and below. In practice the distance from the radium to the film depends upon the number and size of the castings to be radiographed at one time and upon the definition desired. Radium for non-destructive testing may be rented at very small cost.

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or polarizing material that causes the light to vibrate in one plane only), then through the transparent model (bakelite, celluloid, etc.) of the part or joint, and then through an analyzer and on to a screen. For a given model, the screen will show a series of light and dark bands characteristic of the loading conditions. Stress concentrations occur wherever there is a marked *crowding* together or *abrupt curving* of the bands.

Comparisons of different designs are readily made by studying stressed model patterns of these designs; it is usually evident what changes should be made. The mechanism for this study may be a simple reflecting type of polariscope, or a more elaborate projection set-up. Several examples of better designs, lower joint cost by keeping excess metal to a minimum, and improved procedure and therefore lower cost—all achieved through the use of photoelastic analysis—are described. (4)

Testing Duralumin Corrosion

"Electrode Potential Measurements as a Means of Studying the Corrosion Characteristics of Wrought Aluminum of the Duralumin Type." Hugh L. Logan. *J. Res. Nat. Bureau Standards,* Vol. 25, Sept. 1940, pp. 315-325. Investigation.

The reliability of predictions of susceptibility of duralumin-type alloys to intercrystalline corrosion from measurements of electro-chemical potentials was investigated. The potential determinations are most accurately made by charging a condenser, by means of a galvanic cell consisting of a calomel electrode and the alloy, and discharging the condenser through a calibrated ballistic galvanometer. The relative potential of a material can be determined by setting a potentiometer to a predetermined potential and determining from the galvanometer deflection whether the potential is greater or less than the chosen value.

The predicted susceptibilities to intercrystalline corrosion were compared with the results of accelerated-corrosion tests, carried out by immersing specimens for 48 to 72 hrs. in a solution of sodium chloride and hydrogen peroxide. A potential of —0.657 volt (temp. 25° C.) was selected as the critical solution potential.

Intercrystalline corrosion in some degree was correctly predicted from ballistic galvanometer measurements in 98.6% of the 24ST specimens that were rated by corrosion tests as subject to severe intercrystalline corrosion. Susceptibility or immunity to intercrystalline attack was correctly predicted in 87% of all specimens.

Intercrystalline corrosion in some degree was correctly predicted from potential measurements with the potentiometer method on 91% of the 24ST specimens that were susceptible to severe intercrystalline corrosion. Correct predictions of susceptibility or immunity of material to intercrystalline corrosion were made by the potentiometer method on 85.5% of all the specimens.

There was insufficient material available to determine whether 0.657 v. is a satisfactory critical potential for 17S and German duralumin. It is recommended that the potential method of predicting susceptibility to intercrystalline corrosion be used by scientifically trained personnel to supplement rather than to replace the present accelerated corrosion test.

WAT (4)

Fast Coating Thickness Tester

"Magnetic Ultra-Micrometer." W. B. Ellwood. *Bell Labs. Record,* Vol. 19, Sept. 1940, pp. 37-38. Descriptive.

A new rapid method for determining the average thickness of non-magnetic films of metal, paint, paper, etc. on magnetic base material is described.

Two magnetic circuits, which have the test specimen between them as a common part of both circuits, are compared. The non-magnetic film on one side of the specimen introduces a gap in one of these otherwise identical circuits, thereby unbalancing them. The bridge is first balanced with a strip of uncoated iron having a thickness equal to that of the specimen. The change in resistance required to balance the bridge when the coated specimen is inserted is a measure of the thickness of the film.

JZB (4)

Spray Test for Corrosion of Irons and Steels

"An Accelerated Spray Test for the Determination of the Relative Atmospheric Corrodibility of Ferrous Materials." T. Swinden & W. W. Stevenson. *Iron & Steel Inst.,* Adv. Copy, Sept. 1940, 14 pp. Investigation.

An automatic accelerated spray test is described in which the specimens, on an endless belt, complete a cycle of treatment, consisting of spraying, followed by drying in air in a warm chamber. The cycle is completed in 7 min. and the specimens are subjected to 60 cycles per day. A standardized douching with water is given on the second day and on subsequent days. The test is completed in 20 days.

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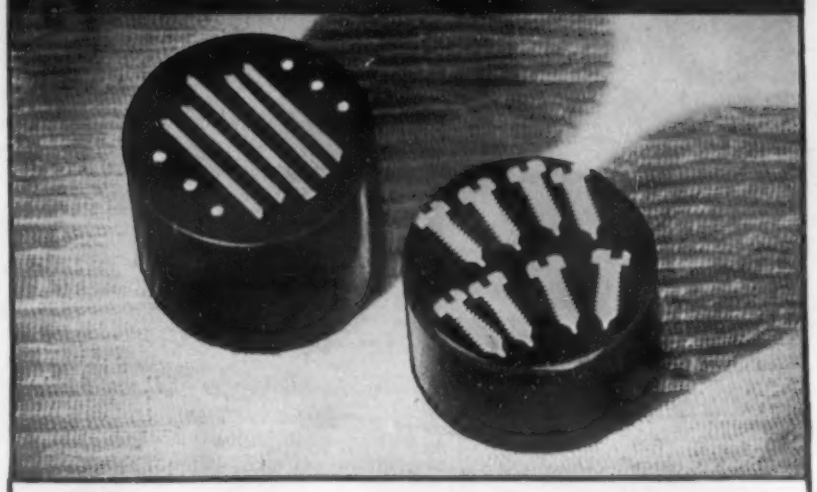

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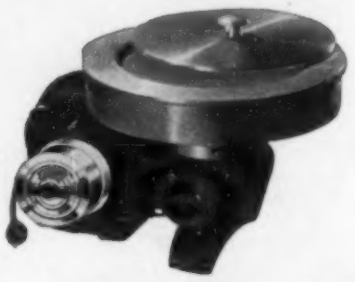

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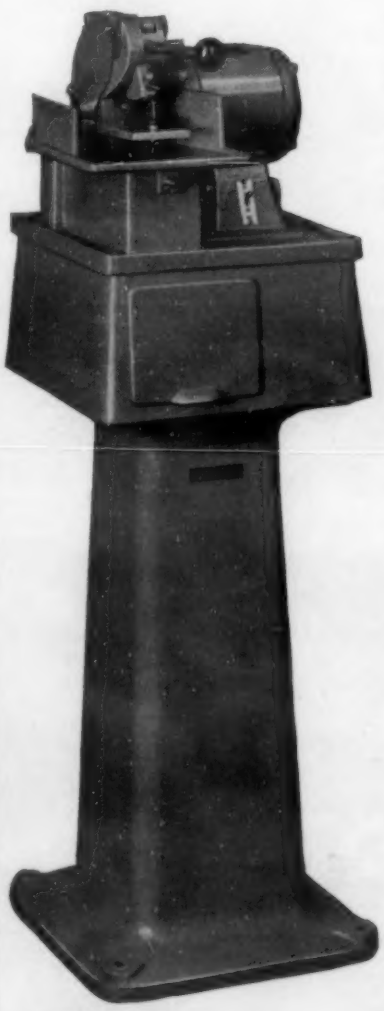

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Results of the test were correlated with one-year atmospheric exposure, and the test graded 14 irons and low-alloy steels in the proper order. The most promising spray was found to be a solution of N/100 H_2SO_4 and N/100 NaCl. N/100 H_2SO_4 without NaCl and N/20 H_2SO_4 did not give so good a correlation with atmospheric exposures. In spraying it is necessary to have the spray form individual drops on the specimens.

Other precautions to be observed are: (1) The spray should consist of very fine droplets, each surrounded by air, and (2) the stainless steel control specimen should not be completely wetted, for excess spray liquid on the specimens reduces the rate of oxygen supply to them. JLG (4)

Determining Deep-Drawability

TESTING OF DEEP DRAWING MATERIALS BY THE WEDGE-DRAW-CUPPING TEST ("Die Prüfung von Tiefziehwerkstoffen durch das Keilzug-Tiefungsverfahren") WILHELM PÜNGEL. *Stahl u. Eisen*, Vol. 60, June 27, 1940, pp. 570-571. Review and research. (For earlier work, see METALS AND ALLOYS, Vol. 9, June 1938, p. MA 369 L 5, and Vol. 10, June 1939, p. MA 358 R 5.)

This sheet testing method (the Kayseler method) was developed to provide a better way of judging the deep-drawing qualities of sheets drawn in several draws. The method has been continually improved and numerous practical hints are given for the procedure of wedge drawing to attain conclusive results in the subsequent Erichsen cupping tests.

In the test, a wedge-shaped specimen of definite dimensions taken from the sheet to be tested is drawn out to a rectangular shape through a prismatic die. With a 10-13 mm. diam. punch, the Erichsen test is then made on various places of the sample thus deformed, the various parts of which have, of course, undergone different degrees of cold work. Depending on the degree of deformation upon drawing, the cupping depth will be different at the various places of the sample where the Erichsen test is made. These values are related to the Erichsen values of the non-deformed as-delivered sheet, *i.e.* the elongation of a certain section of the wedge upon drawing is plotted against the remaining cupping depth (100% in the as-delivered state) in percentage of the cupping depth of the non-deformed sheet.

Practical experience with the method, which has been successfully applied to ordinary low-carbon sheets and to various types of alloy and stainless steels, are reported, with particular attention to work on automobile body and copper sheets, sheets of 18-8 chromium-nickel stainless steel, an 18-9 chromium-manganese steel and a 15% chromium steel.

According to the common Erichsen values as usually determined, the chromium-manganese steel would possess deep-drawing properties similar to those of copper, whereas the 15% Cr sheet would be much less fit for deep-drawing. This result is not in accordance with practical experience. In the wedge-draw cupping test, however, the cupping values of the chromium-manganese steel decreased considerably even after small degrees of cold work whereas the Erichsen values of the chromium steel in dependence on the degree of deformation decreased much less. This *is* in agreement with practical experience.

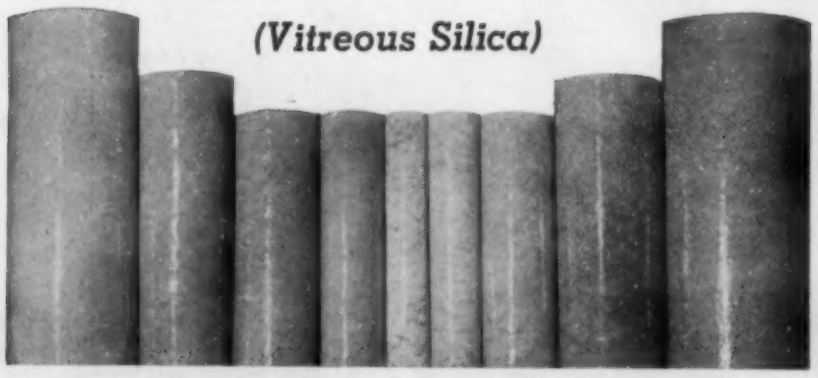
Of particular interest are experiments in testing different sheets for processing milk cans. The sheets from 2 different plants behaved quite differently in forming the can necks. Sheet A showed no difficulties, whereas sheet B cracked in this operation. Neither chemical composition nor the ordinary Erichsen values provided an explanation for this different behavior. Also, the wedge-draw cupping test showed no considerable differences.

However, after drawing the wedge-draw samples at 400° F., the Erichsen values were totally different. Sheet A, after a 20% deformation in wedge-drawing at 400° F. still possessed 75% of the Erichsen value of the as-delivered sheet, but sheet B showed merely 25-35% after the same treatment. Since the production neck-forming brings about a considerable temperature-increase, sheet B would have been proven as unsuitable in advance by applying the wedge-draw cupping test.

An advantage of the Kayseler method is the possibility of directly comparing sheets of different thicknesses, something that is impossible with the other sheet testing methods. [*This is the first comprehensive research report on this new method, which evidently has passed the experimental stage. This reviewer used one of the first of Kayseler's wedge-draw apparatuses years ago, but encountered certain difficulties in practical procedure, which despite all further perfections in the apparatus still make this testing method too difficult and tedious for routine testing. From the fundamental viewpoint, however, Kayseler's research must be highly welcomed.*—G.N.] GN (4)

LARGE VITREOSIL PIPES

(Vitreous Silica)



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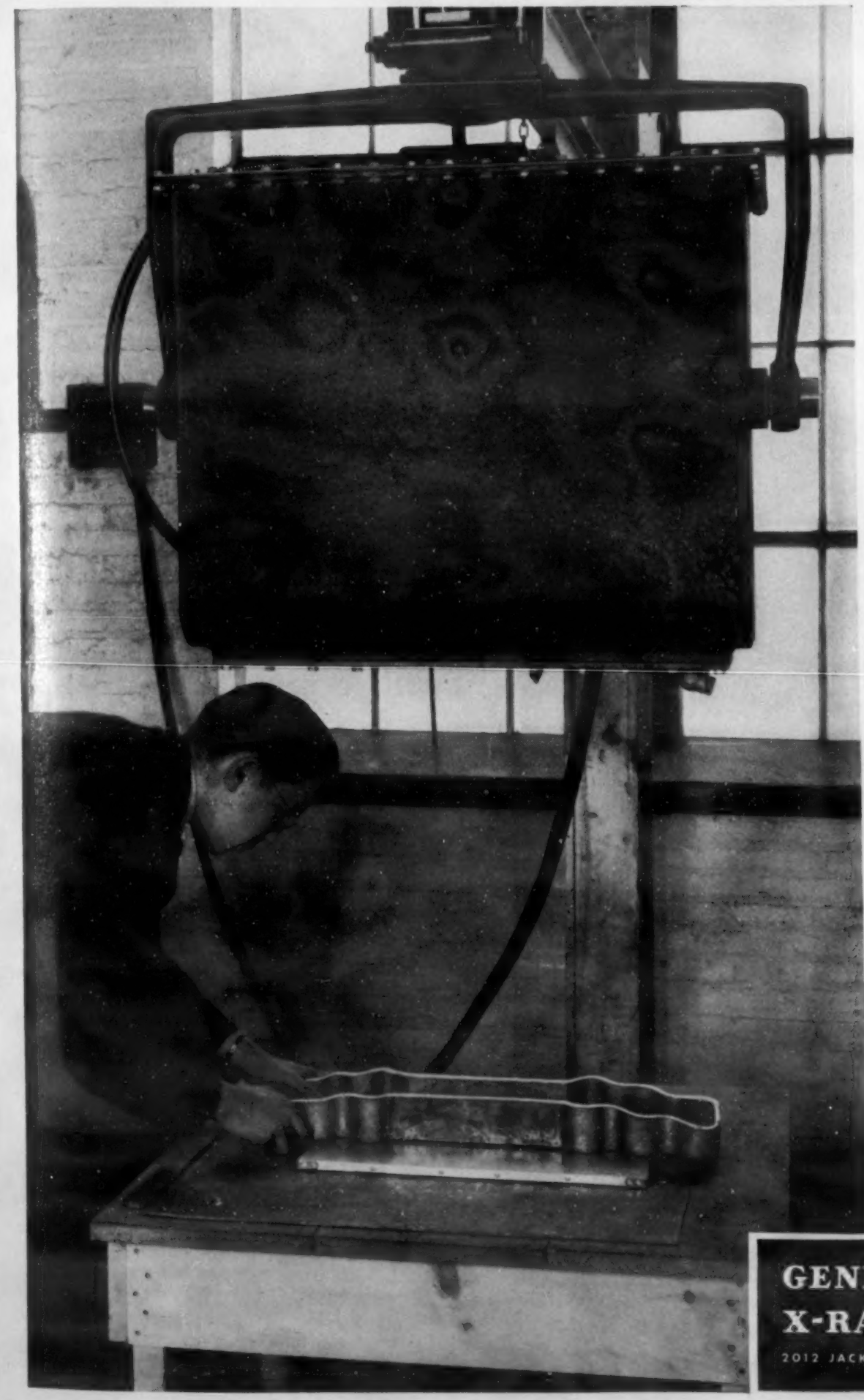

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books

Magnesium Alloys

MAGNESIUM AND ITS ALLOYS (Magnesium und seine Legierungen). *By A. Beck. Published by Julius Springer, Berlin, 1939. Paper, 6½ x 9½ in., 520 pages. Price 54 RM.*

This worthwhile addition to the published literature on magnesium deserves more than the usual notice a new book receives. To date there has been no other attempt to write a comprehensive treatise on magnesium. The results in this case are admirable, and the book is one that every metallurgical engineer concerned with making, working or using magnesium will want on his desk.

The editor of this book has wisely had the chapters written by a number of specialists. Almost all of these men are from the I. G. Farbenindustrie, and therefore definitely on the "inside" of the German magnesium industry. A great deal of the material in the book has never appeared in English, and some has never before been published anywhere. The long period of development of magnesium in Germany combined with large tonnage in use in aviation, transportation, and machine equipment has supplied the authors with valuable experience regarding the characteristics of magnesium alloys in service.

The chapters deal with raw sources, production, physical properties of single crystals, metallography, phase diagrams of known alloys, physical properties, strength properties, chemical behavior, corrosion and surface protection, melting and sand casting technique, chill casting, die casting, extrusion, forging, rolling, machining operations of all kinds, construction-design details and applications, magnesium as an alloying element in other metals, pyrotechnics, thermochemistry, chemical analysis procedures, and finally, a complete list of patents issued on magnesium classified as to subject matter and country of issue.

The chapter on strength characteristics should be particularly mentioned for its thoroughness (134 pages) and for the information on many special properties. The chapter on the properties of magnesium single crystals is particularly interesting. The latter chapters dealing with the design and manufacture of various industrial products out of magnesium alloys are also of special interest.

The book, however, is not perfect. In the chapter on casting technique we find considerable theorizing but only meager data on the iron refining process, while regarding superheating effects on grain size some elementary facts are presented with no attempt to explain this very interesting phenomenon. It is safe to say that the corrosion behavior of the alloys as presented in several of the graphs is not representative of the basic nature of magnesium alloys, but rather is due to the presence of unnecessary impurities. Extensive strength comparisons made between the 6 per cent Al, 3 Zn and the 9 per cent Al, ½ Zn alloys are invalid because only the latter were in the heat-treated state. There are a few obvious omissions, such as the failure to mention the use of magnesium for photo-engraving, or the technique of casting high quality billets for extrusion or rolling. The chapter on analysis is lacking in that it fails to mention spectroscopic methods, which are very important.

While these and other important omissions must be noted, yet the book as a whole is an excellent treatise on magnesium.—J. D. HANAWALT.

Oxidation-Resistant Alloys

METALS AND ALLOYS FOR HIGH TEMPERATURES (Metalle und Legierungen für hohe Temperaturen. 1 Teil: Zunderfeste Legierungen). *By W. Hessenbruch. Published by Julius Springer, Berlin, 1940. Paper, 6½ x 9½ in., 254 pages. Price 30 RM.*

This highly specialized book, part of Köster's general series on *Reine und angewandte Metallkunde in Einzeldarstellungen,* presents a well-balanced account of practical experience and present scientific knowledge of oxidation-resisting alloys.

The principal chapters of the book are the following: (1) Physico-chemical reactions during the formation of protective coatings; (2) composition of oxide and other protective coatings; (3) methods of determining resistance to scaling; (4) effect of various alloying elements on resistence to scaling; (5) effect of small alloy additions on "life at elevated temperatures," (6) reactions between heat-resistant metals and alloys and gaseous media (except air and oxygen); (7) special applications of non-scaling alloys; (8) effect of the manufacturing process on heat-resistant alloys.

Regarding the last chapter, one would have expected a fascinating report on Dr. Hessenbruch's extensive experience with commercial vacuum melting at Hanau. Unfortunately, the author remains reticent on this subject, and his generalities on the superiority of vacuum melting must remain disputable so long as alloys melted by other processes yield about the same results in service. By presenting actual experimental data on the problems of commercial vacuum melting, the author would have rendered a unique and outstanding service. Aside from this, however, the reader is allowed to profit generously from the author's extensive experience with high temperature alloys.

For the first time, a truly comprehensive presentation of the effect of small alloying additions on the resistance to scaling is given. The drastic effect of such additions as revealed here opens a wide field for further development of heat-resistant alloys, and the author's book provides a valuable guide for engineers dealing with the commercial production and application of such high-temperature alloys as well as for investigators approaching the subject from the purely scientific viewpoint. The relatively large number of 231 illustrations and 51 tables enhances the value of the book to those who read German only with difficulty.

The volume can be highly recommended. —ERICH FETZ.

Mining Directory

MINES REGISTER.—1940 EDITION. *Published by Atlas Publishing Co., Inc., New York, 1940. Cloth, 6 x 9 in., 942 pages. Price $25.00.*

Volume XX of the Mines Register, 1940 Edition, successor to the Mines Handbook, is the first appearance of this book since the 1937 edition. The many changes in the non-ferrous mining industry in this country, Canada, Mexico and South America have been carefully checked. This new edition contains a description of more than 7,000 active mining companies, and lists more than 24,000 inactive mines.

A special section is devoted to listing mining engineers, mine managers, superintendents, etc.—E. F. CONE.

Other New Books

METALLURGICAL ABSTRACTS. *Volume 6, 1939. Edited by S. C. Guillan. Published by The Institute of Metals, London, 1939. Cloth, 5¼ x 8½ in., 683 pages. Price £4, which includes two bound volumes of the Institute's Journal.* Short abstracts on non-ferrous and general topics published in magazines throughout the world. Coverage is practically complete with respect to non-ferrous literature.

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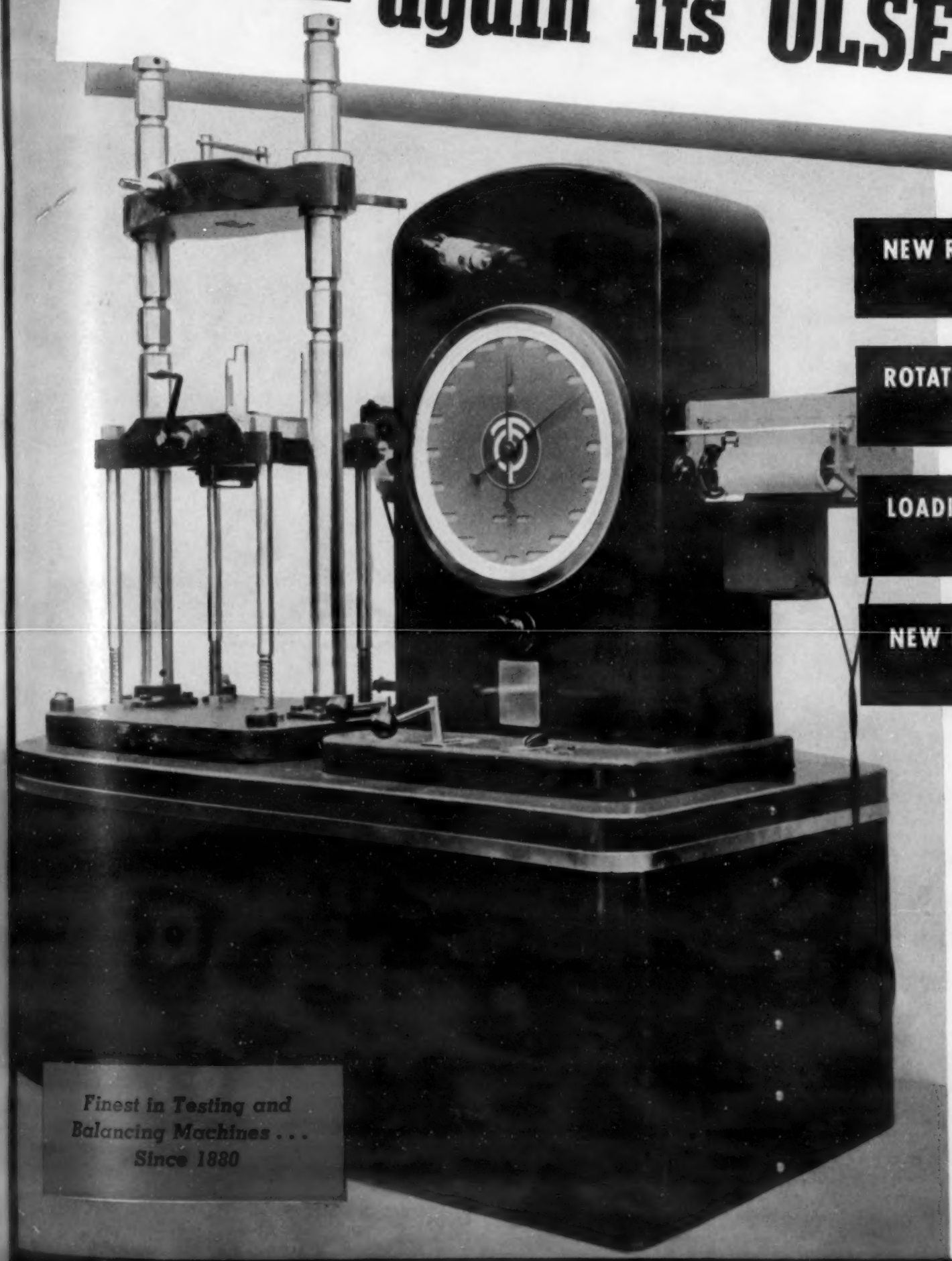

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METALLURGICAL ENGINEERING

shop notes

High-Oxygen Atmospheres for Hardening Tool Steels

by Walter A. Schlegel
Carpenter Steel Co.

In the August 1940 issue of METALS AND ALLOYS, (page 226) we discussed the desirability of having a slightly oxidizing atmosphere (rather than a "reducing" atmosphere) for hardening certain tool steels, and described a simple, practical "wood-block" method for checking oxygen contents under 6 per cent oxygen, as recommended for use with plain carbon and certain high-silicon, carbon-tungsten, carbon-manganese or low-alloy tungsten-chromium-vanadium tool steels.

For oil-hardening tough tool steels like Carpenter R. D. S. (0.75 per cent C, 1.75 per cent Ni and 1.0 per cent Cr) an atmosphere containing between 8 and 10 per cent excess oxygen is best. For such an atmosphere the wood-block method cannot be used, since there is no significant change in the flame from a wood block above 5½ per cent oxygen. With steels of this type the atmosphere may be checked by observing the behavior of either a gas torch flame or a small piece of soft coal when inserted in the furnace atmosphere.

In using the gas torch, the gas pipe can be bent to project through one of the roof ports without reaching the bottom of the furnace. The torch should be lighted before insertion in the furnace, and the valve adjusted to produce a flame 3-in. long. Then, with the flame burning, insert the torch in the furnace and observe it through the peephole in the door.

At a hardening temperature of about 1525-1550 deg. F. (best for this steel), the gas torch will burn with a pale blue flame—practically non-luminous — if the oxygen content is 5½ to 6 per cent. (If this flame is hard to see, pinch the rubber tube to make the flame intermittent, when it will be more visible.) The flame will be partly luminous—a blue base with a luminous tip—if the oxygen content is between 6½ and 7 per cent. Finally, the flame will be all luminous—the full luminosity characteristic of the gas being used—if the atmosphere contains 7½ to 10 per cent excess oxygen. This last atmosphere is the best one for the type of steel under discussion.

In all cases, the flame in the furnace will usually be much larger than it was in the air. If the furnace is small use a small tube, since the torch flame consumes some of the oxygen in the atmosphere. For this reason also, the observations should be made *immediately* after insertion of the torch.

Another simple method is to place a piece of soft coal (about ½-in. cube) on a flat piece of scale-resisting sheet metal (*e.g.* stainless steel) in the furnace, with the furnace gases able to circulate freely past it. Below 4 per cent excess oxygen, the coal will merely smoke, without "burning." At higher oxygen contents, flame will appear mixed with smoke, until at about 10 per cent the smoke has practically vanished. In atmospheres containing 8 to 10 per cent excess oxygen, the soft coal ignites with only a trace of smoke, and burns with a clear luminous flame. The remaining coke definitely glows.

With the furnace running uniformly at the hardening temperature, adjust the atmosphere with the aid of either of the foregoing methods to 8-10 per cent oxygen. Then put the cold steel directly in the hot furnace, without preheating, and after it has come to temperature, let it soak for 5 min. per in. of thickness, and quench in oil.

With the atmosphere and procedure recommended, this chromium-nickel tool steel will free itself of scale during the oil quench, will be uniformly hard, and will suffer no appreciable change in surface carbon. Such results may be had in either an atmosphere-controlled electric furnace, or in a semi-muffle type of furnace fired with oil or gas.

This steel will also harden satisfactorily from an electric muffle furnace *having no artificial atmosphere* at all, provided simply that the atmosphere in the furnace does not become stagnant. In a subsequent article we'll offer some practical pointers on atmosphere practice as affected by the *type of furnace* used for tool-hardening.

One of the secrets of successfully cutting steel with cemented carbide cutting tools is to run the operation fast enough to prevent the formation of a built-up edge on the tools; a "starting" speed of 300 ft. per min. is recommended. Coolants should be applied from below, and individually piped to each point of contact. A 1/32-in. radius ground in the tool-point aids the cutting operation.

—Carboloy Company

In crushers furnished to mining companies in Northern latitudes, much breakage occurred with carbon steel shafts during the winter months. The trouble has been largely eliminated by using for such service a low carbon 3¼ per cent nickel steel, which retains its impact strength at low temperatures.

—*Inco*, International Nickel Co., Inc.

The usual procedure in hardfacing the corners of various types of mill hammers has been to rebuild each corner as square as possible. A stunt currently growing in favor is to "pile on" the hardfacing alloy (Stoodite, for example) so as to bring each corner out to a bevel or peak—using extra metal and a sharper point. The extra amount of hard-metal naturally keeps the hammers in operation longer and thus further reduces maintenance costs.

—*Fusion Facts*, Stoody Co.

(MORE "SHOP NOTES" ON PAGE 838)

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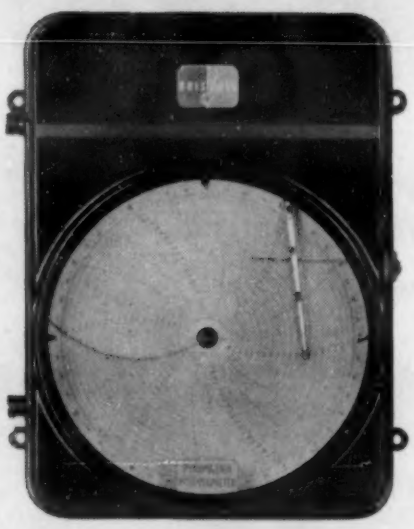

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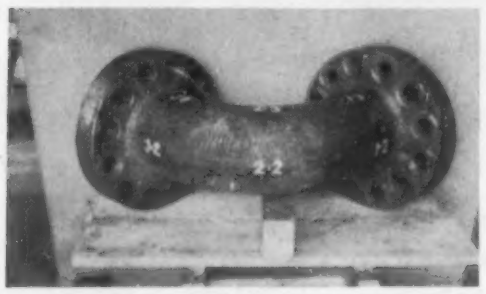
Heavy Flanges on Steel Castings

by H. R. Isenburger
St. John X-Ray Service, Inc.

Heavy flanges on steel castings can easily be the cause of cracks in the finished casting, if the change in section from the body to the flange is made too abruptly.

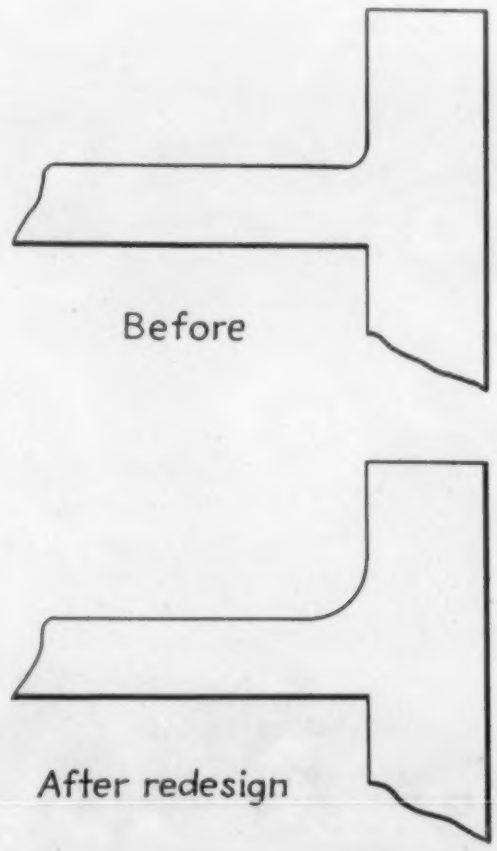
Such cracks ("hot tears") result because the lighter section (the wall in the "ell" fitting illustrated) has completely solidified and is contracting rapidly while the thicker section (the flange) is still solidifying; the different contracting rates thus set up cause stresses, and cracking occurs close to the change in section.

The "ell" fitting illustrated is a good example of the need for careful design of castings to avoid hot tears. Thirteen fittings of this type were submitted for X-ray inspection before installation. More than



half of them had cracks in the wall area adjacent to the flange, as shown in the exograph. The defect extended well into the flange and was due to the abrupt change in thickness between the wall and the flange.

The recurrence of this defect in subsequent castings was prevented by simply redesigning the fillet, as indicated in the sketch, to provide a more gradual change in section.



"Engineering" is the function by which technical knowledge is translated into practical production- and design-results, and "metallurgical engineering" is this function applied to the manufacture, fabrication, treatment and application of metals and metal-forms. Knowing why *must therefore be supplemented in every successful case with knowing* how, *and metallurgical engineers—the readers of this magazine—are no exception in their eager interest in the many little practical kinks and quirks that enable them to make things better, cheaper, or more conveniently.*

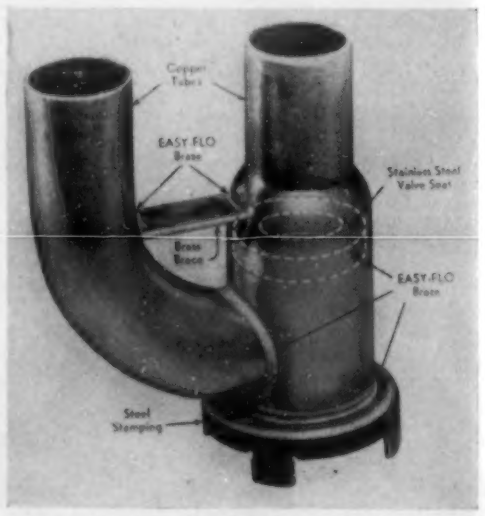
So send in your "Shop Notes"—the department is becoming one of the magazine's most popular, and METALS AND ALLOYS *will pay contributors for each original item accepted.—The Editors.*

Brazed Parts vs. Castings

by M. C. Robbins
Handy & Harman

Parts that conventionally would be made of castings can often be manufactured instead by brazing, with notable savings in time and cost. The silver brazing alloys, which have melting points between 1150 and 1600 deg. F., are particularly useful in this respect because they flow freely at low temperatures, yet provide strong joints.

The heater valve body illustrated, for example, was assembled entirely by brazing. It is made of 2 pieces of tubing with 20 B. & S. gage walls, a brass bracing piece between the curved and straight tubes, a



stamping of steel at the base and a valve seat of stainless steel inserted inside the large diameter of the straight tube.

In production, the entire part was set up and fluxed. Rings of brazing alloy wire were pre-placed around the joints to be made, and then the assembly was put in a furnace and brazed in one operation. The brazing alloy used was a silver alloy called "Easy-Flo" (manufactured by Handy & Harman, New York), which has a medium silver content and flows freely at 1175 deg. F.

Designing for brazing not only eliminates casting and the machining of parts, but silver alloy brazing permits the joining of several dissimilar metals. In this instance copper, brass, steel and stainless steel were permanently bonded together. The joints in this case had to be leak-tight, and it is reported that finished parts, which are being made in quantity, are coming through satisfactorily and with a very low percentage of rejects.

"Orange peel" finish obtained on spray-painting of metals can often be traced to an unsuitable thinner. A thinner containing a high percentage of low-boiling or cheap solvents will cause "orange peel" regardless of how the material is applied. Other causes are (1) insufficient atomization; (2) gun held too far from surface; (3) gun held so close to the surface that the air ripples the latter; (4) paint material not thoroughly dissolved or agitated; (5) with synthetics and lacquers—too low humidity, or drafts in the finishing room.

—"ABC of Spray Painting Equipment," The De Vilbiss Company

By using an iron rod as a stirrer and fluxing agent, flame-gouging can successfully be done on steel impregnated with sand.

—*Oxy-Acetylene Tips,* Linde Air Products Co.

In grinding tool steel and alloy steel billets, rate of cut and rate of wheel wear are proportionate to surface speed of the wheel. Wheel wear per unit of work ground remains constant regardless of wheel speed. Economy is gained through the higher rate of production. Higher pressure increases both rate of cut and rate of wheel wear.

—*Grits and Grinds,* Norton Company

How Calcium Alloys Help to Improve Steel . . . . . .

CALCIUM ALLOYS are rapid and effective deoxidizers for steel. Added to acid steel, these alloys improve fluidity and eliminate porosity in castings. Calcium forms strong basic oxides which combine with acid oxides and thus cleanse the steel by forming low-melting-point inclusions which coagulate and rise rapidly out of the bath. Calcium alloys help to eliminate gases by increasing the fluidity of the molten steel. They do not reduce grain size when used alone; thus they do not decrease machinability. Calcium alloys are not harmful if used inadvertently to excess.

"Electromet" calcium alloys include calcium-silicon, calcium-manganese-silicon, and calcium-aluminum-silicon. One of our metallurgists will gladly call and explain further the function of these alloys and how they can be used to best advantage. This service is yours for the asking.

ELECTRO METALLURGICAL COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York, N. Y.

Items of Interest about other "Electromet" Ferro-Alloys

•

Manganese Raises High-Temperature Ductility of Stainless Steels—From 1½ to 4½ per cent of manganese in stainless steels of the austenitic chromium-nickel type increases their ductility at high temperatures, and thus facilitates hot-working and improves weldability. These benefits are of particular advantage in modified 18-8 stainless steels; in 25-12 chromium-nickel steels; and in 25-20 chromium-nickel steels.

Nitrogen Improves Properties of High-Chromium Steel Castings—Tests show that nitrogen in cast steels containing over 20 per cent chromium increases ultimate strength, yield point, reduction of area, and elongation. Machinability is not sacrificed. Corrosion resistance is unimpaired. Nitrogen can be easily added as high-nitrogen ferrochrome.

Columbium or Titanium Prevents Intergranular Corrosion in Chromium-Nickel Steels—The addition of columbium or titanium to austenitic steels containing 18 to 30 per cent chromium and 8 to 20 per cent nickel eliminates intergranular corrosion. The columbium content should be from 6 to 10 times, or the titanium content from 4 to 6 times, the carbon content.

Calcium-Silicon Simplifies Pouring of Steel Castings—Calcium-silicon used as a ladle deoxidizer

cleanses the steel and increases its fluidity. Steel treated with calcium-silicon flows freely right to the end of the pouring period. This simplifies pouring practice.

Columbium Improves 4 to 6 Per Cent Chromium Steels—When wrought 4 to 6 per cent chromium steels contain a small amount of columbium, they do not air-harden, and are more ductile even in the as-rolled state. They have higher creep strength, toughness, and oxidation resistance at elevated temperatures. Welding and cutting are facilitated.

• • •

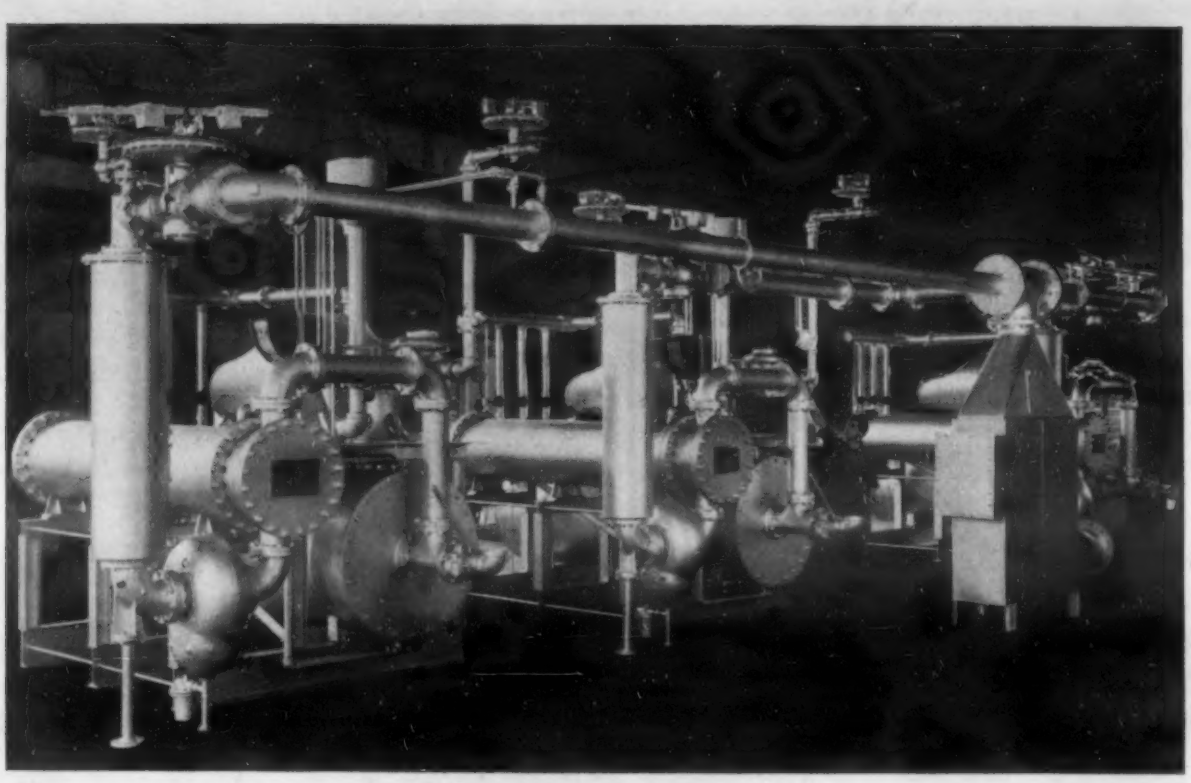
If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

Electromet
Trade-Mark
Ferro-Alloys & Metals

Available through offices of Electro Metallurgical Sales Corporation in Birmingham, Chicago, Cleveland, Detroit, New York, Pittsburgh, and San Francisco. In Canada: Electro Metallurgical Company of Canada, Ltd., Welland, Ont.

The word "Electromet" is a registered trade-mark of Electro Metallurgical Company.

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION



EVERY DAY IS

M-DAY *for* STEEL

Nothing but the best in Men, Methods, Machinery can meet the demands that hemisphere defence puts upon the industry.

Outstanding in late developments in bright annealing is the Kemp Atmos-Gas Producer, controlled by the Kemp Constant Analysis Monitor, an "electrical nervous system" that maintains inflexible standard.

In this reliable, time-tested equipment, operators find the guardian of forced-draft production, accuracy of control that will hold to a consistent new low. Write for Bulletin 101.14. **Address The C. M. Kemp Mfg. Co., 405 East Oliver St., Baltimore, Maryland.**

KEMP of BALTIMORE

Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION · FABRICATION · TREATMENT · APPLICATION

NOVEMBER 1940

Mg

MAKES BINOCULARS EASIER TO HANDLE

Obviously, it is desirable to make binoculars as easy to handle as possible. The less weight the less fatigue in holding them in position.

Fee and Stemwedel, Inc., in designing the pair shown at right, have reduced weight to the minimum by using the remarkably light metal, magnesium (Mg). Parts, including the large inner casing, are DOWMETAL* Magnesium Alloy die castings, supplied by The Doehler Die Casting Company.

Magnesium, strong and durable, is a full third lighter than any other metal in common use. Manufacturers in many fields are therefore taking advantage of DOWMETAL to streamline their products. For these useful magnesium alloys lend themselves to all the usual methods of fabrication and assembly.

In addition to die castings, DOWMETAL is available in sand and permanent mold castings, forgings, sheet, strip, plate, bars, tubes, structural and special extruded shapes. Write for any information desired.

DOWMETAL

MAGNESIUM ALLOYS

LIGHTEST OF ALL STRUCTURAL METALS

THE DOW CHEMICAL COMPANY, MIDLAND, MICH.

Branch Sales Offices: New York City, St. Louis, Chicago, San Francisco, Los Angeles, Seattle.

*Trade Mark Reg. U. S. Pat. Off.

for *Mechanized* Preparedness

Let our metallurgists help you put these special-purpose steels to work

HERE in U·S·S Cor-Ten and U·S·S Man-Ten and U·S·S Abrasion Resisting Steel, are service-tested steels that seem specially made-to-order for the situation that faces American industry today.

Low in cost, easy to fabricate, these tough, hard-wearing, high-strength steels can be economically applied to make both stationary and mobile equipment of all kinds more efficient than ever before. Able to do more work. Longer lasting. Less expensive to operate. Cheaper to keep up. Less liable to break-down.

There's nothing new or untried about these U·S·S High Tensile Steels. They've proved their fitness in thousands of applications. You will find them in lightweight freight cars that carry extra tons of payload capacity in place of excess weight . . . in trucks and trailers that weigh less, travel faster and carry bigger loads . . . in earth-moving and materials-handling equipment that consistently sets new records in moving bigger tonnages at lower cost for power. Applied in marine service, their ability to resist abrasion and corrosion means increased life and maintenance savings.

If your product seems adapted for these materials, why not call in our metallurgical specialists. They will gladly talk over the possibilities and economics of U·S·S High Tensile Steels as applied to your designs.

USS ABRASION RESISTING STEEL

U·S·S ABRASION RESISTING STEEL

Meets the requirements for a high strength, durable yet low priced steel for general applications where the material is subject primarily to abrasion. With a manganese content of 1.5% to 2%, it costs little more than plain steel, yet for some applications has been found to wear as well, even better sometimes, than higher priced alloys. In the as-rolled condition A-R Steel has a tensile strength of approximately 100,000 to 125,000 p.s.i. and a Brinell hardness of 200 to 250, depending on the gage.

U·S·S Abrasion Resisting Steel has been successfully applied to prolong the life of coke-handling equipment, chutes for handling coal, or rock, gravel and sand. Its economy and usefulness have been demonstrated in screens, concrete mixer parts, pug mill liner plates, furnace skips and hoppers, in dredge and pontoon pipe, conveyor parts, as well as in road machinery.

U·S·S HIGH TENSILE STEELS

U·S·S COR-TEN · U·S·S MAN-TEN · U·S·S ABRASION-RESISTING STEEL

AMERICAN HOT DIP Galvanizers Association

STRATEGICALLY LOCATED WITH REFERENCE TO STEEL

WHEREVER THERE'S A NEED . . . THERE'S A MEMBER

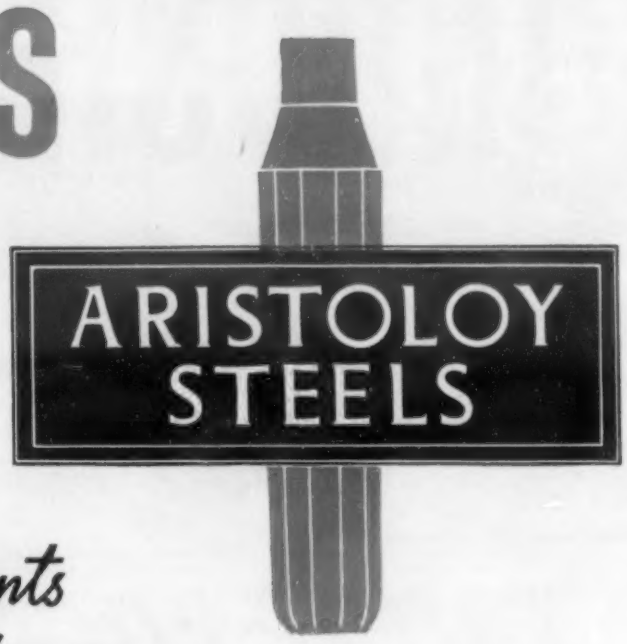
Rigidly *adhering* to the highest standards of quality at reasonable prices, *maintaining* the most modern and completely equipped shops, *employing* expertly trained personnel, *enjoying* the constant help of an efficient research department, this association represents *the* pioneering, stabilizing anchor of the galvanizing world . . . It is *your guarantee* of getting good work quickly and a genuine Hot Dip Job every time . . . Why gamble—deal with a *known* quality—patronize our very conveniently located members. WE ARE ORGANIZED FOR HIGH SPEED, EFFICIENT PRODUCTION. American Hot Dip Galvanizers Association, Inc., American Bank Bldg., Pittsburgh, Pennsylvania.

IF IT CARRIES THIS SEAL IT'S A JOB WELL DONE

Know the truth about Galvanizing. Write for official specification sheet and new folder giving actual data on life of Hot Dip Galvanized Products under various conditions.

Acme Galvanizing, Inc., Milwaukee, Wis. ★ Acme Steel & Malleable Iron Works, Buffalo, N. Y. ★ American Tinning & Galvanizing Co., Erie, Pa. ★ Atlantic Steel Co., Atlanta, Georgia ★ Buffalo Galvanizing & Tinning Works, Inc., Buffalo, N.Y. ★ Diamond Expansion Bolt Co., Inc., Garwood, N.J. ★ Equipment Steel Products Division of Union Asbestos and Rubber Co., Blue Island, Ill. ★ The Fanner Mfg. Company, Cleveland, Ohio ★ John Finn Metal Works, San Francisco, Cal. ★ Thomas Gregory Galvanizing Works, Maspeth, N.Y. ★ Hanlon-Gregory Galvanizing Co., Pittsburgh, Pa. ★ Hubbard & Co., Oakland, Cal. ★ Independent Galvanizing Co., Newark, N.J. ★ International Derrick & Equipment Co., Columbus, O. ★ Joslyn Co. of California, Los Angeles, Cal. ★ Joslyn Mfg. & Supply Co., Chicago, Ill. ★ L. O. Koven & Brother, Inc., Jersey City, N. J. ★ Lehigh Structural Steel Co., Allentown, Pa. ★ Lewis Bolt & Nut Company, Minneapolis, Minn. ★ Missouri Rolling Mill Corp., St. Louis, Mo. ★ The National Telephone Supply Company, Cleveland, Ohio ★ Penn Galvanizing Co., Philadelphia, Pa. ★ Riverside Foundry & Galvanizing Company, Kalamazoo, Mich. ★ San Francisco Galvanizing Works, San Francisco, Cal. ★ The Sanitary Tinning Company, Cleveland, O. ★ Standard Galvanizing Co., Chicago, Ill. ★ Wilcox, Crittenden & Company, Inc., Middletown, Conn. ★ The Witt Cornice Company, Cincinnati, O.

QUICKER DELIVERIES OF ALLOY STEELS



Now you can get Quicker Shipments of Aristoloy Steels in all these Forms, Finishes and Conditions:

Steels

S.A.E. ALLOY STEELS; OXIDATION AND CORROSION RESISTING STEELS; TOOL AND SPECIAL STEELS; AIRCRAFT QUALITY STEELS; STAINLESS STEELS

Forms

B L O O M S; B I L L E T S; B A R S

Finishes

HOT ROLLED; MACHINE STRAIGHTENED; TURNED

Conditions

AS ROLLED; HEAT TREATED; ANNEALED SPHEROIDIZED; TEMPERED

ARISTOLOY S.A.E. ALLOY BILLETS AND BARS; OXIDATION AND CORROSION RESISTING STEELS; TOOL AND SPECIAL STEELS; AIRCRAFT QUALITY STEELS; STAINLESS STEELS

COPPERWELD STEEL COMPANY · WARREN, OHIO

INDUSTRY calls for *speed* ...*more speed*

And GAS comes through with stepped-up production, new economies

The accelerated trend to Gas for industrial heating processes today is peculiarly significant. It is proof that this modern fuel—quick-heating, accurately controllable, flexible, and economical—has all the characteristics to recommend it for the speedier production that industry demands.

Gas is quick-heating—which means shorter time cycles, faster production. Gas is accurately and automatically controllable, both as to temperature and furnace atmosphere—which means precision manufacture, better quality, fewer rejects. Gas is flexible and adaptable to any plant layout—which means it can be fitted into a production operation quickly, easily and economically. And Gas is low in cost—which means production economy, bigger profits.

Investigate Gas for your plant. Your Gas Company will show you how Gas can step up your own production and, if you wish, give you facts on how other companies in your line have used Gas equipment to solve specific problems in manufacturing.

AMERICAN GAS ASSOCIATION

INDUSTRIAL GAS SECTION . . . 420 LEXINGTON AVE., NEW YORK CITY

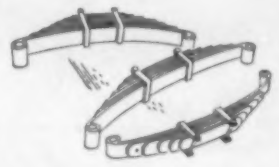
CASE HISTORIES

Proof that Gas Speeds Production, Improves Quality, Cuts Costs

1. "One new Gas-fired radiant tube furnace increased output 2½ times that of two previously used furnaces using another fuel"—Wilson Steel and Wire Co., Chicago.
2. "Our work calls for precision control with speed. Low-cost Gas meets this requirement perfectly"—National Supply Co., Torrance, Calif.
3. "Better Product—25% fuel saving" with gas, says Forsberg Manufacturing Co., Bridgeport, Conn.

GAS... preferred fuel for all industrial heating

The Detroit plant of Eaton Manufacturing Company finds that Gas and modern Gas equipment make for both efficiency and economy in hardening and tempering a wide variety of springs. Equipment used comprises Gas-fired draw furnaces using the modern principle of recirculated air. Close control of temperature and atmosphere assures uniformity, reduces "rejects" and gives unusual flexibility of production.



Gas thus plays its part, with modern Gas equipment, to produce high-grade springs—just as it does in many other metals industries. Wherever there is a heat treating problem, Gas and modern Gas-fired equipment can offer real advantages.

And the Soule Steel Company of San Francisco—to name another plant—finds Gas of advantage in producing rust-proofed steel sash. It built in the West the largest bonderizing plant in existence there, and obtained smooth efficiency and continuous operation with the help of Gas company engineers. "Only Gas fuel," says this company, "could give us the necessary self-contained mechanical and thermal efficiency. Quick, unvarying temperatures at such low cost are possible with no other fuel."

There's no heating energy so efficient—or flexible—or economical—as Gas for hardening, annealing, tempering, normalizing, carburizing and a score of other industrial heating processes. Gas is the preferred fuel because it is quick heating, clean, flexible, accurately controllable and highest in utilization value.

Whatever your industrial heating requirements, your Gas company can offer helpful advice. Why not find out what Gas and the latest Gas-fired equipment can do for you?

For Making Silicon Additions to Open-Hearth Steel . . . . . Use 20 to 30% Ferrosilicon

THE USE of 20 to 30 Per Cent Ferrosilicon instead of the lower-silicon grades of this ferro-alloy or high-silicon pig iron for making silicon additions to steel in the open-hearth furnace gives you a number of advantages. The silicon content in the 20 to 30 per cent grades is more concentrated, so that smaller additions are required to give the desired effect. This simplifies and speeds up the melting process. These higher-silicon grades are still heavy enough to fall readily through the slag into the molten bath. The 20 to 24 per cent grade is the ferro-silicon of maximum silicon content that can be handled by electro-magnets.

Ask to have one of our metallurgists call and explain further how you can benefit by the use of 20 to 30 Per Cent Ferrosilicon. Your request for this service will not obligate you.

ELECTRO METALLURGICAL COMPANY

Unit of Union Carbide and Carbon Corporation

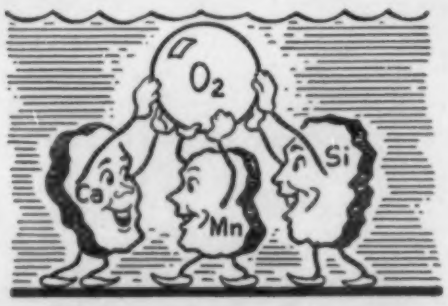
30 East 42nd Street UCC New York, N. Y.

Items of Interest about other "Electromet" Ferro-Alloys

•

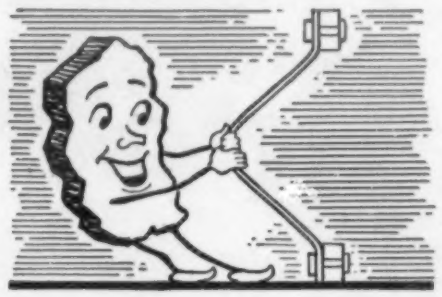
Silico-Manganese Simplifies Production of Low-Carbon Manganese Steel – Silico-manganese is a quick and effective deoxidizer for both acid and basic open-hearth steel. The low carbon content of this alloy, coupled with its rapid cleansing action, simplifies the making of low-carbon manganese steel and facilitates close control of final carbon content.

Calcium-Manganese-Silicon Is A Good Deoxidizer for Wrought Steels – Calcium-manganese-silicon is a powerful cleansing agent for wrought steels because it includes three strong deoxidizers in a combination which is more effective than separate alloys containing these elements. It leaves the steel extremely clean and free from harmful, segregated inclusions. Also, calcium-manganese-silicon does not mask the effect of grain-refining agents, and hence can be used in conjunction with them for producing clean, fine-grained steels.

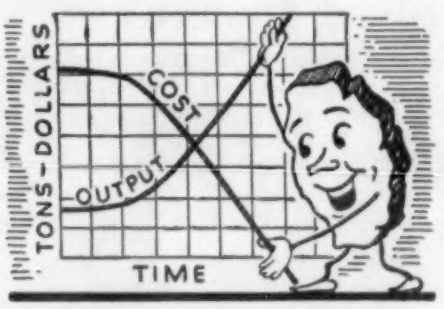


Use Calcium-Silicon in the Ladle for Making Coarse Grained Steels – The use of calcium-silicon as a ladle deoxidizer in rolled steels improves soundness while still maintaining a coarse grain size. Coarse-grained steels are more responsive to heat-treatment and deep-hardening.

Zirconium Is Effective for Reducing Age-Hardening of Deep-Drawing Steels – The use of zirconium in deep-drawing steels decreases age-hardening and thus minimizes cracking even in the most severe draws. Zirconium ties up the nitrogen which is to a large degree responsible for age-hardening, and renders it harmless.



Medium-Carbon Ferromanganese Increases Furnace Output – In the production of low-carbon steel, medium-carbon ferromanganese introduces less carbon to the bath than standard ferromanganese. Consequently, oxidation of the bath need not be as severe, furnace time is materially shortened, and furnace output is increased.



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If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

Electromet
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Ferro-Alloys & Metals

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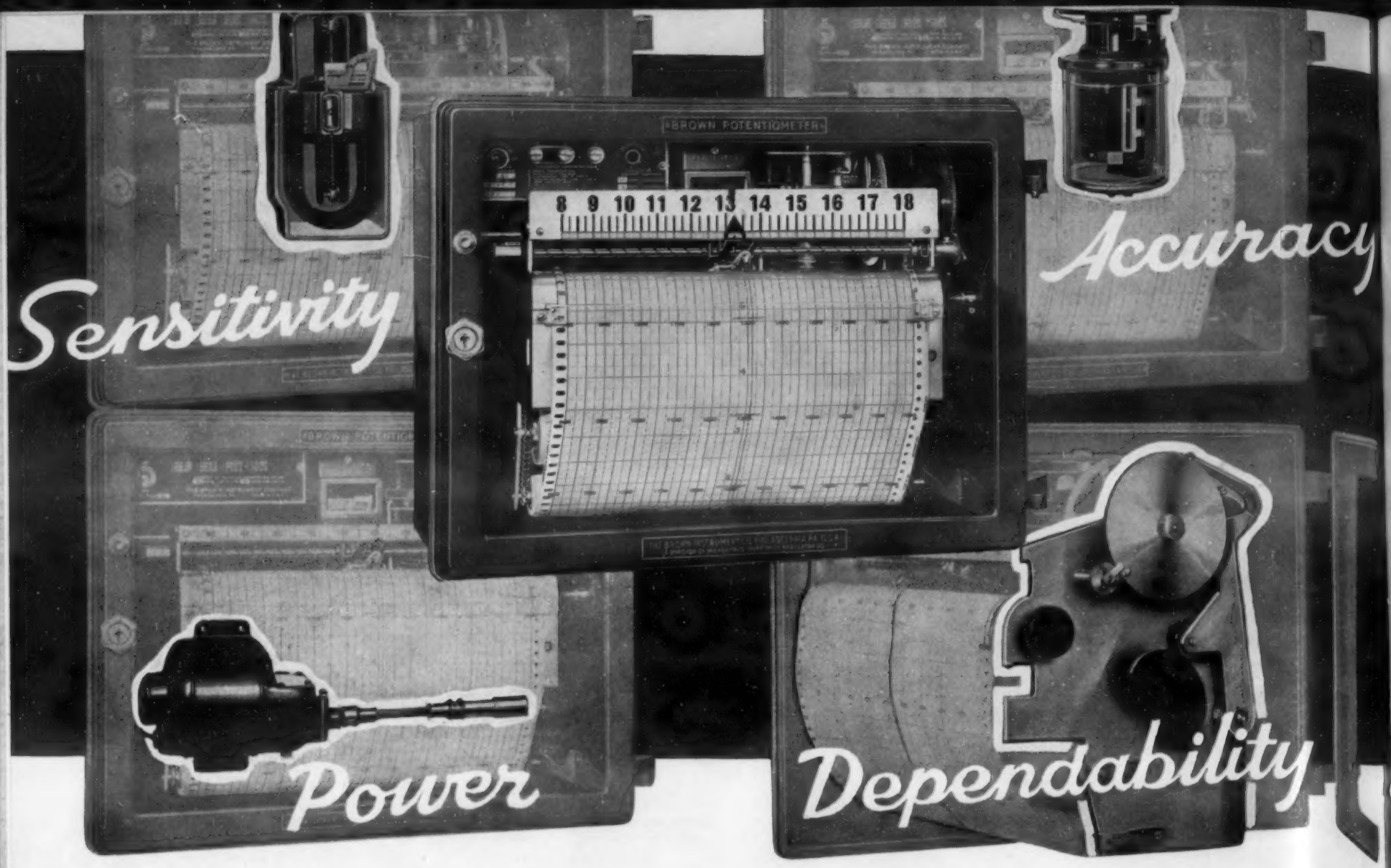

UNIT CONSTRUCTION *Permits* QUICK DELIVERY

Brown Potentiometer Pyrometers are rugged, precision-built instruments and guaranteed to give the performance required for industrial service today or tomorrow.

Like a fine automobile, the working parts of these instruments are assembled into major units.

Because of our expanded facilities and modern manufacturing methods, an ample supply of Brown Potentiometer Pyrometer Units is now in stock—ready to be calibrated and assembled to meet your specific requirements.

The mighty industrial defense program is geared to run at a tremendous pace. SPEED UP! SPEED UP! is today's demand in the Metal Working Industry.

It is our desire to assist you in every way possible to speed up production. Write, phone or wire our nearest branch. Tell us your need. . . . We'll follow through if you need charts, ink, marking ribbons, thermocouples, protecting tubes, and extension lead wire . . . in fact, every standard item you need can be shipped immediately.

Leading metallurgists who demand prompt delivery, extreme precision and reliable measurement and temperature control of all types of electric, gas, or oil-heated units specify Brown Potentiometer Pyrometers to improve quality, reduce costs.

THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4517 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Toronto, Canada: 117 Peter Street — Amsterdam-C, Holland: Wijdesteeg 4 — England: Wadsworth Road, Perivale, Middlesex, — Stockholm, Sweden: Nybrokajen 7.

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Get the facts about Brown Periodic Service. Discover how little it costs you to have your instrument investment protected by a nationwide organization of factory-trained service engineers who already supply Brown Periodic Service to more than 2,000 industrial plants.

BROWN POTENTIOMETER PYROMETERS

AND

MINNEAPOLIS · HONEYWELL CONTROL SYSTEMS

To Measure and Control is to Economize

A MICHIANA SUGGESTION MAY SAVE YOU TROUBLE, TOO

MAKING so wide a variety of alloy castings —studying these applications and checking performance has given MICHIANA a storehouse of experience of value to all users of heat- and corrosion-resistant alloys.

Difficulties Eliminated — Costs Reduced

Frequent breakages of heat-resistant alloy chains in heat treating furnaces brought MICHIANA in to investigate the costly difficulties.

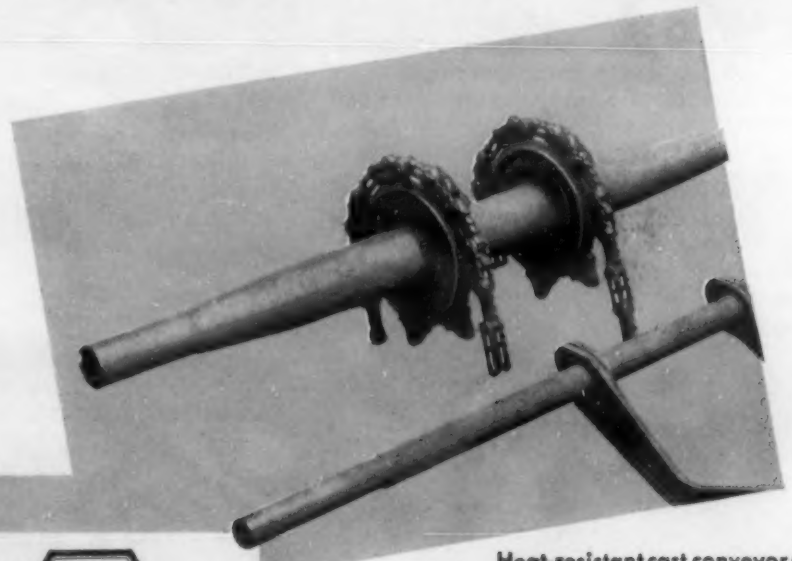
Correction had been attempted by increasing the chain weight, but a study of all the factors disclosed the fact that the sprocket designs were the cause of the trouble. With redesigned sprockets, much lighter and less costly MICHIANA alloy chains proved satisfactory and frequent breakages and production delays were eliminated.

Consult MICHIANA on Alloy Castings

This typical case is cited to illustrate our policy of cooperation. Nearly a quarter-of-a-century specialized experience is at your service . . . A MICHIANA suggestion before the work is started may save valuable time, expense and trouble later.

You can place your requirements with MICHIANA with full confidence of thorough handling from receipt of specifications and prints to the finished castings.

MICHIANA PRODUCTS CORPORATION
MICHIGAN CITY **INDIANA**



Heat-resistant cast conveyor chain, with sprockets and shafts also of heat-resistant alloy—for a continuous heat-treating furnace.

MP CORP.

Retorts • Rails
Pots • Boxes • Grids
Sprockets • Chains
Rolls • Tubes

Heat-Resistant and Stainless Steel Alloy Parts of all kinds.

MICHIANA
Heat-Resistant and Stainless Steel
ALLOY CASTINGS

manufacturers' literature

Yours for the Asking

1. FERROUS METALS

Silvery Pig Iron

A well-written and informative 20-page booklet of Jackson Iron & Steel Co. gives the story of silvery pig iron, its history and manufacture, with particular attention to the importance of slag control in pig iron quality. (1-102)

Surface-Hardened Stainless Steel

The principle and applications of the Drever-Industrial process for surface hardening stainless steels and the new combination of wear- and corrosion-resistance that it offers the designer are discussed in a 4-page bulletin of Drever Company. (1-99)

New High Strength Steel

A carefully prepared 4-page bulletin of Otis Steel Co. gives the composition, mechanical properties, corrosion resistance and fabricating properties of Otiscoloy, this company's low alloy, high yield strength steel. (1-98)

Molybdenum in Steel

The fundamental effects of molybdenum in steel are explained with striking clarity in a 16-page informative technical bulletin of Climax Molybdenum Co., which covers the effects on properties, fabrication and treatment. (1-100)

Nitriding Steels

The Nitralloy Corp. has just issued a 29-page engineering booklet (prepared by Dr. Homerberg) that covers in complete detail the whole field of nitriding—suitable steels, condition of steel, the nitriding process, applications in industry, etc. (1-33)

Stainless Steel Machinability Chart

A handy celluloid slide-chart that presents at a glance the best speeds, feeds, etc., for turning, forming, threading, drilling, tapping and reaming each of a large number of stainless steels is offered by Industrial Steels, Inc. (1-85)

Moly High-Speed Steels

Firth-Sterling Steel Co. offers a bulletin on Mo-Chip high-speed steel, a new steel for taps said to offer an unusual combination of required hardness and extraordinary toughness. (1-65)

Air Hardening Die Steel

Windsor Special air hardening die steel is inexpensive, tough, non-deforming, easily machined and conveniently hardened, according to a data-filled 4-page folder of Jessop Steel Co. (1-101)

Stainless Machinability Chart

Practical operating data for machining stainless steels are available at a glance through the use of Rustless Iron & Steel Corporation's machinability chart for stainless steels. (1-67)

2. NON-FERROUS METALS

Copper Alloys

A compilation of data on the composition and physical properties of the coppers, brasses, bronzes, nickel silvers, beryllium coppers and other copper alloys sold by American Brass Co. is presented in a handy little folder. (2-106)

Tool Steels

"Tool Steel for the Non-Metallurgist" is the title of a 28-page reprinted article, of interest to many of our readers, issued by Crucible Steel Co. of America. Practical engineering data on the properties and uses of tool steel are presented. (2-107)

Special Bronzes

A 16-page booklet of Ampco Metal, Inc., entitled "Brief Facts About Ampco Metal," describes the 6 grades of this wear-resistant and corrosion-resistant high-aluminum, high-iron bronze, and discusses its many industrial applications. (2-105)

Phosphor Bronze

The Phosphor Bronze Smelting Co. has issued a 44-page catalog of Elephant Brand phosphor bronze wire, sheets, rods and tubes, and other alloy products. (2-72)

Magnesium Alloys

Magnesium and its alloys, and their industrial value from the standpoint of lightweight design, are discussed in the booklet "Industry's Lightest Structural Metal," published by Dow Chemical Co., Dowmetal Div. (2-104)

Copper, Brass and Bronze Weights and Data

A comprehensive and detailed 32-page catalog of Revere Copper & Brass, Inc., presents tabular weight data for various sizes and thicknesses of copper, brass and bronze products. Distribution is limited to engineers, draftsmen, estimators and designers. (2-82)

Tungsten, Molybdenum and Alloys

The versatile experience and varied line of products of Callite Tungsten Co. are featured in a bulletin describing special refractory Callite alloys, carbides and other unusual metallurgical products. (2-49)

Bibliography on Indium

A highly useful 22-page list of references to articles published throughout the world since 1933 on indium—its extraction, properties, alloys, economic factors, uses, etc.—is available from Indium Corp. of America. (2-91)

New Aluminum Casting Alloy

Information on composition, foundry practice and properties of T-1 aluminum alloy, claimed to give tensile strength of 33,000 lbs./in.^{2} without heat treatment, is given in a 4-page bulletin of National Bronze & Aluminum Foundry Co. (2-69)

Electrolytic Manganese

A new product, 99.9+% electrolytic manganese now being produced on a commercial scale, is completely described in a folder of Electro Manganese Corp. The properties of aluminum-, zinc-, copper- and nickel-base alloys containing manganese and of new and ductile alloys containing major proportions of manganese are discussed. (2-55)

3. METAL FORMS · METAL PARTS · ENGINEERING DESIGN

Alloy Steel Locomotive Forgings

Manganese-vanadium steel forgings (normalized and tempered) for railroad applications are discussed informatively in a 4-page bulletin of Vanadium Corp. of America. (3-73)

Strong Aluminum Alloy Castings

The properties and applications of the new Ti-Aluminum alloy castings, Nos. 40 and 40E, said to offer unusually high strength through natural aging (without heat treatment), are described in a 4-page bulletin of Frontier Bronze Corp. (3-77)

Metal for Cast-to-Form Dies

A 4-page illustrated booklet gives data on the properties and performance of Meehanite for cast-to-form dies. Meehanite Research Institute. (3-64)

X-Ray Tested Castings

Grades and applications, physical properties and many typical designs and products available in Thermalloy X-ray inspected alloy castings for heat and corrosion-resistant service are presented in a 16-page bulletin of Electro Alloys Co. (3-74)

Seamless Steel Tubing

A wealth of useful descriptive and application data on seamless mechanical tubing, of carbon or alloy steel, is contained in an illustrated 8-page bulletin of Ohio Seamless Tube Co. (3-71)

High-Strength Bronze

A new leaflet describing the uses and advantages of DHS bronze for mechanical parts and equipment used in rolling mills and other steel-manufacturing equipment has been issued by Koppers Co., Bartlett-Hayward Div. (3-75)

Zinc Alloy Die Castings

"What Industry Thinks of Zinc Alloy Die Castings" is the title of a 20-page booklet discussing several specific instances where the use of zinc alloy die castings in the design of a product has consistently enhanced its value. New Jersey Zinc Co. (3-67)

Oven-Door Sight Glasses

Pyrex sheet glass and oven-door panels specially designed for service as sight glasses in metallurgical furnaces, ovens and in chemical process equipment are discussed, with diagrams and price data, in an 8-page bulletin of Corning Glass Works. (3-72)

Wear Resistant Precious Metal Parts

Permo Products Corp. has issued a bulletin describing Permo metal, a smooth wear-resistant, corrosion-resistant alloy of osmium, rhodium and ruthenium, said to be useful for instrument bearings, fountain pen tips, phonograph needles, contacts, etc. (3-65)

Electrical Contacts

A new 16-page catalog illustrating and describing Gibsiloy electrical contacts made from powdered metals has been issued by Gibson Electric Co. and covers 8 standard silver-base contact materials. (3-76)

Bimetals and Electrical Contacts

H. A. Wilson Company's Blue Book of thermometals and electrical contacts contains 48 pages of useful, illustrative, engineering information of aid to designers in the selection of metals and alloys for these applications. (3-70)

Nickel-Chromium Alloy Castings

Nichrome, Chromax and Cimet alloy castings for applications requiring high heat resistance are informatively discussed in a readable 36-page booklet, which features several useful designs for cast heat treating equipment. Driver-Harris Co. (3-69)

Non-Ferrous Alloy Parts

A wide range of non-ferrous alloys offering unusual electrical or mechanical properties for various applications—from electrical contacts and resistance welding electrodes to embossing dies and spring washers—is completely described in a 16-page catalog of P. R. Mallory & Co., Inc. (3-68)

Self-Lubricating Bearing Press Fits

A new sleeve bearing data sheet of Johnson Bronze Co. indicates graphically the amount of closing when a Ledaloyl self-lubricating bearing is given a .002-in. or .003-in. press fit in the housing. (3-66)

Self-Lubricating Bearings

An attractive, interesting and highly useful 16-page catalog of R. W. Rhoades Metaline Co., Inc. discusses Metaline "oilless" bronze bearings, and includes engineering data and illustrations of many applications. (3-46)

Ductile Iron Castings

An interesting discussion of Z-Metal—a specially-treated, ductile alloy cast iron—is presented from the engineering viewpoint in a 10-page booklet of Ferrous Metals Corp. Comparisons with steel forgings, steel castings, malleable iron castings, etc., are included. (3-57)

4. MELTING · REFINING · CASTING

(See also Section 6)

Ferro Alloys, Deoxidizers, Etc.

Electromet products and service are discussed in a pocket-size 24-page reference booklet of Electro Metallurgical Co. The alloys described are used for deoxidizing, scavenging, degasifying, alloying, grain refining, graphitizing, etc. (4-49)

Centrifugal Casting Machines

The construction and performance of the vertical centrifugal casting machines manufactured by Centrifugal Casting Machine Co., and said to be applicable to the casting of ferrous and non-ferrous metals, are outlined in an interesting 4-page bulletin. (4-48)

Core Binder

Two publications of Hercules Powder Co.—the first a description of Truline binder and its applicability, with comparative data for other binders, and the second a brochure outlining "What Hercules Is Doing for the Foundry"—are offered. (4-32)

Crucible Furnaces

Descriptive details and complete specifications for Walker-York coke-fired crucible melting units for the foundry, in capacities from 80 lbs. to 1,000 lbs., are given in a highly useful 6-page bulletin of Crucible Furnace Co., Inc. (4-35)

Cutting Crucible Costs

The Crucible Manufacturers' Assn. has issued a useful and interesting 16-page booklet on the storing, handling and use of melting crucibles. Useful alloy data are also included. (4-36)

Die Coating and Mold Dressing

Procedure for application, quantities and prices for Bonis die coating and mold dressing for non-ferrous die and permanent mold castings are given in a leaflet of St. John X-Ray Service, Inc. (4-50)

5. HEAT TREATMENT · HEATING

(See also Section 6)

Austempering

An interesting 12-page booklet of U. S. Steel Corp. describes in simple, straight-forward fashion the possibilities for developing high hardness-toughness combinations in steel by the austempering process of constant-temperature heat treatment. (5-139)

Furnaces, Burners, Etc.

The new condensed catalog and data book (No. 602) of American Gas Furnace Co. is issued in the form of a handy wire-bound 118-page thumb-index catalog containing usefully-detailed descriptions of the standardized burners, furnaces and heating machines manufactured by this company for hardening, tempering, carburizing, forging, annealing, brazing, etc. (5-144)

Carburizing Baths

The advantages claimed for Holden carburizing baths, together with operating cost data and illustrations of typical micro-structures obtained, are outlined in a 4-page bulletin of A. F. Holden Co. (5-137)

Fuel-Oil Gasifier

American Gasifier Co. describes in an interesting 4-page folder the principle, applications, performance and advantages of this company's Gasifier—a device that generates gas from No. 1 fuel oil. (5-138)

Tempering and Aging Furnaces

Despatch Oven Co. has published new bulletins explaining the engineering features and performance of furnaces for tempering of steel and alloy parts and for age-hardening of non-ferrous alloys. (5-136)

CONTINUED NEXT PAGE

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Steel Protection

The procedure of using Sel-Car and its claimed advantages for protecting steel from decarburization during heat treatment and for selective case hardening of certain areas, etc., are discussed in a 6-page bulletin (No. 112) of National Copper Paint Corp. (5-143)

Industrial Furnaces

The wide range of uses for Stewart furnaces (heat treatment, tempering, annealing, non-ferrous melting, forging, coating, etc.) is manifest in the comprehensive, well-indexed and illustrated 75-page industrial furnace catalog of Chicago Flexible Shaft Co. (5-140)

Furnaces and National Defense

The applications of SC furnaces in the manufacture of armor plate, aircraft parts, shells, cartridge cases, bombs, gun tubes and mounts, etc., are briefly described and illustrated in a 4-page bulletin of Surface Combustion Corp. (5-142)

Duplex Compressors

Compressors of the direct-connected electric-driven and the flat-belt, V-belt or other drive types from 50 to 250 h.p. for single or multi-stage compression are described in a well-illustrated 36-page catalog of Ingersoll-Rand. (5-141)

Blast-Gates

A comprehensive 12-page catalog of W. S. Rockwell Co. covers a full line of slide and butterfly blast-gates for controlling the flow of low-pressure air in heat treating furnaces, ovens, cupolas, dryers, etc. (5-146)

Gas Combustion Equipment

An interesting 4-page folder of National Machine Works reviews this company's combustion devices for gas fuel, as applied to industrial furnaces and ovens. Torch tips, blast line burners, low-blast burners, air heaters, proportional mixers and other units are described. (5-145)

Combustion Control System

The Isley system of regenerative furnace combustion control and its application to soaking pits, slab, bloom and billet heating furnaces, and forging furnaces, are discussed in an illustrated 8-page bulletin. Morgan Construction Co. (5-89)

High Frequency Converters

High frequency electric converters for use in conjunction with numerous industrial induction heating applications are described. Lepel High Frequency Laboratories, Inc. (5-124)

Liquid Bath Electric Furnaces

An illustrated 4-page bulletin of Bellis Heat Treating Co. reviews the construction, operation and application of Bellislavite electrode-type furnaces for annealing, tempering, case-hardening, hardening, and heating for forging. (5-87)

Blowerless Furnaces

Baker small gas-fired furnaces that operate at 1850 to 2300 deg. F. without blower or compressed air are discussed in an illustrated 8-page booklet of Baker & Co. Applications in tool-room, dental laboratory, for treating high-speed steel, for bright annealing and for fluxless brazing are described. (5-59)

Control of Furnace Atmosphere

Two bulletins devoted to a description of "Certain Curtain Control of Atmosphere" and to furnaces for pre-heating and hardening high-speed steel have been issued by C. I. Hayes, Inc. (5-33)

Carburizing Unit

The Hevi-Duty Carburizer is an electric furnace unit using the Carbonol (carefully blended gas-producing oil) process, which is claimed to provide uniform case depth, improvement in quality, cleanliness and other advantages. Hevi Duty Electric Co. (5-2)

High Speed Steel Heat Treating Furnaces

Juthe electric furnaces for heat treating high speed steel are discussed in a leaflet of American Electric Furnace Co. These furnaces feature atmospheric control, cleanliness and close temperature maintenance. The furnace is said to lend itself particularly to rapid economical hardening of small tools. (5-57)

6. REFRACTORIES • INSULATION

Foundry Refractories

Ironton cupola blocks, ladle bottom tile, ladle pouring brick, ladle linings and other cupola specialties are described and illustrated in a 4-page bulletin of Ironton Firebrick Co. (6-41)

World-Wide Refractories

A 48-page export booklet of General Refractories Co., printed in both English and Spanish, describes the major types of refractories, their uses and methods of shipment. (6-39)

High-Temperature Bonding Mortars

From the opening suggestion, "select your bond to match your brick," through to its interesting finish, the 16-page booklet of Harbison-Walker Refractories Co. on high temperature mortars offers much sound and useful information about these materials and their applications. (6-40)

High Temperature Insulation

An illustrated leaflet is devoted to types and uses of thermal insulation, for all types of heating equipment. Armstrong Cork Co. (6-10)

Fire Clay Products

Various Goose Lake fire clay products—brick, flour, bond, standard fire clay, and high-silica clay—and Therm-O-Flake high temperature insulation are described in a folder of Illinois Clay Products Co. (6-30)

7. WELDING • CUTTING

Aluminum Bronze Welding Rod

Engineering data sheets Nos. 81 and 82 of Ampco Metals, Inc., describe Ampco Weld—a coated Ampco Metal welding rod—said to be the first coated aluminum bronze welding rod available to industry. (7-53)

New Brazing Alloy

Phos-copper, a brazing alloy made in rod, ribbon and special shapes by Westinghouse Elec. & Mfg. Co., is useful for manufacturing, for installations, and for maintenance, and has several unusual properties, according to a 4-page bulletin. (7-51)

Resistance Welding Control

A new 8-page engineering bulletin of General Electric Co. provides a complete description of Thyratron resistance welder controls for accurate and reproducible spot and projection welding, and gives operating data. (7-58)

Eutectic Welding Rod

Castolin eutectic (low-temperature) alloy welding rods for gas-welding aluminum alloys, magnesium alloys, copper alloys, nickel alloys, cast irons, steels, alloy steels, zinc-base die castings and other metals are described in a data-sheet folder of Eutectic Welding Alloys, Inc. (7-52)

Rocker-Arm Spot Welders

Air-operated rocker-arm type spot welders (types 0, 1, 2 and 3) manufactured by Acme Electric Welder Co. speed production, relieve operator fatigue and make uniform automatic spot welds, according to a 4-page bulletin. (7-57)

Welding Directory

In a comprehensive new 60-page bulletin the Lincoln Electric Co. gives complete procedures for making all types of welds on all important industrial metals and for applying hard surfacing material. A special feature is a chart to aid in the selection of electrodes. (7-56)

Joining Nickel Alloys

A gold mine of practical engineering information on the welding, brazing and soft soldering of Monel, nickel and Inconel is presented in a new 32-page technical bulletin (No. T-2) of International Nickel Co., Inc. (7-59)

Electric Salt Baths for Brazing

A new 24-page catalog describes the Ajax Hultgren furnace and its applications for high- and low-temperature heat treating and annealing as well as for brazing and heating for forging. Ajax Electric Co., Inc. (7-55)

Electrode Selector Chart

Air Reduction Sales Co. is issuing an electrode selector chart to guide arc welders in the determination of the type of electrode, welding practice, etc., according to the metal to be welded. (7-50)

Resistance Welding Electrodes

Electroloy alloys for resistance welding electrodes, dies and auxiliary equipment are described in a new catalog of Electroloy Co., Inc. Bar stock, forgings and castings in these alloys are also discussed. (7-54)

Stainless and Heat Resisting Electrodes

Price list and data book containing descriptions of the company's products and analyses of stainless and heat resisting alloys manufactured by other companies. Maurath, Inc. (7-2)

Stainless Welding Electrodes

Eight pages of illustrated description, with fabular engineering data, on Arcos electrodes for welding stainless steel and also bronze, cast iron, special mild steel and nickel electrodes are given in a useful bulletin of Arcos Corporation. (7-42)

High-Tensile Welding Wire

Literature on welding rod and wire, particularly Page Hi-Tensile "G," for work with the new high-tensile steels and alloys, is available from Page Steel and Wire Division, American Chain & Cable Co., Inc. (7-12)

8. FORMING · FORGING · MACHINING

Hot Plate Mill Gauge

The Haines Gauge Co. has issued a 4-page descriptive bulletin on its automatic micrometer rolling-mill gauges for measuring plate, sheet or bar thickness during hot rolling operations. (8-58)

Carbide Tool Chip-Breaker Grinder

Carboloy Co., Inc., offers a technical bulletin on its new chip-breaker grinder for use with cemented carbide tools designed for the machining of steel, with complete operating instructions. (8-57)

Tool Room Chart

A new Kennametal tool room chart, on which is printed an inch rule and a protractor, shows Kennametal tool designs for turning bar stock and forgings and for turret lathe operations. McKenna Metals Co. (8-60)

Special Tools and Dies

Both standard and special dies, tools and machinery, particularly for the production of single and multiple-operation stampings, are described in a 36-page engineering catalog of S. B. Whistler & Sons, Inc. (8-61)

Grinding Stellite-Type Tools

A highly useful 31-page guide book of Norton Co. gives detailed, illustrated information on best practice for grinding "Haynes Stellite," "J-Metal" and "2400" cutting tools. (8-56)

Working Nickel Alloy Steels

Reprints of a highly-useful set of working practice recommendations for S.A.E. nickel alloy steels—their heat treatment, machining and welding—have been issued by International Nickel Co., Inc. (8-59)

Aircraft Stamping Dies

A reprint of an interesting article describing the use of Kirksite zinc alloy dies for producing stainless steel aircraft stampings is available from National Lead Co. (8-55)

Cutting Oils

Cities Service Oil Co. has published a comprehensive, readable bulletin on the theory and practice of metal cutting lubrication. Types of lubricants and their intelligent application are discussed. (8-19)

Powder Metallurgy Presses, Molds

Several pages of descriptive information about large and small molds and presses for briquetting powdered metals are available from F. J. Stokes Machine Co. (8-54)

9. CLEANING · PICKLING · PLATING FINISHING

Metal-Spraying Periodical

Metallizing Engineering Co., Inc., is now publishing *Metco News*, an interesting periodical devoted to metal-spraying developments and applications from the viewpoints of product manufacture, salvaging and maintenance. (9-78)

Cleaning Castings, Forgings, etc.

A "cleaning quiz" that provides a convenient check-list for evaluating any metal-part cleaning system for its speed, cost, efficiency, labor requirements and surface quality is given in a 4-page folder of Pangborn Corp., makers of RotoBlast cleaning systems. (9-69)

Rust Preventive

American Chemical Paint Co., in a 4-page folder, discusses their "elastic primer," which is claimed to form a rubber-like coating that expands and contracts with the metal, and at the same time inhibits rust. (9-76)

Pre-finished Metals

Much new information on the cost-reducing and quality-improving advantages of pre - finished metal sheets and strips (straight and in coils) is offered in several leaflets of American Nickeloid Co. devoted to production case histories. (9-77)

High-Speed Brass Plating

A new process for producing smooth, bright, heavy brass deposits in ½ to ⅓ the time required by ordinary methods is described, with operating data, in a 4-page bulletin of E. I. duPont de Nemours & Co., Inc., Electroplating Div. (9-75)

Pickling Agent

An attractive and useful 12-page booklet is devoted to Ferrisul, a soluble ferric sulphate claimed to be specially useful for pickling stainless steel and copper alloys and for etching steel before galvanizing or tinning. Merrimac Div., Monsanto Chemical Co. (9-63)

10. TESTING · INSPECTION · CONTROL

Testing Equipment

A rapid-fire, informative summary of Baldwin-Southwark Division's testing, inspection, recording and control equipment, with an index of available descriptive literature by this company is contained in a 6-page leaflet. (10-121)

Measuring Surface Roughness

The use of the Profilometer in providing direct dial readings of surface roughness for meeting specifications on highly-finished metal surfaces is interestingly portrayed in a 4-page bulletin of Physicists Research Co. (10-130)

Furnace Control System

Eight broadly useful applications of the Reactrol system of furnace and heating control in annealing furnaces, heat treating furnaces, electric ovens, air heaters, etc. are graphically described in a 4-page bulletin of General Electric Co. (10-131)

Direct-Reading Brinell Tester

Magnetically - operated direct - reading depth gages and other features of its Brinell and diamond type hardness testers, suitable for testing any material or shape, are discussed in a 4-page bulletin of Gogan Machine Corp. (10-124)

Please Use the Coupon on Page 605

Dial Indicators

Federal Universal test indicators for general tool-room and machine-shop use and also for high production inspection are described and illustrated in a leaflet of Federal Products Corp. (10-125)

Electroplating Control Instruments

Automatic temperature control of electroplating processes as carried out by a leading aero engine manufacturer is interestingly described in an illustrated folder of Foxboro Co. (10-127)

Electronic Devices for Industry

A new 20-page booklet, published by General Electric Co., lists the important applications of vacuum-tube apparatus in industrial control and inspection devices of many types. (10-129)

Gas Analysis Apparatus

Laboratory and portable models of standard Burrell gas analysis equipment and modern gas analysis solutions are reviewed in an illustrated 6-page folder of Burrell Technical Supply Co. (10-128)

Furnace Regulators

A 12-page picture book showing installations of Askania automatic regulators for controlling furnaces in various metallurgical and other industries is offered by Askania Regulator Co. (10-123)

Furnace Pressure Control

The important new features of Leeds & Northrup Company's extensively-redesigned furnace pressure control system for metallurgical and other industrial furnaces are described in a 12-page catalog. (10-122)

Magnetic Analyzers

A leaflet of General Electric Co. is devoted to GE magnetic analyzers for determining the amount of magnetic iron oxide particles present in powdered or granulated non-magnetic materials. (10-126)

Metallurgical Testing Apparatus

The latest edition of *The Metal Analyst*, just out, contains 98 pages of highly useful and attractively presented information on metallographic and metallurgical testing equipment, spectrographic apparatus and optical instruments, and a 1053-reference bibliography on relevant technical publications. Adolph I. Buehler. (10-80)

Surface Pyrometers

Illinois Testing Laboratories, Inc., have prepared a 4-page bulletin on the improved Alnor surface pyrometer, known as the Pyrocon, for measuring surface temperatures of metals or other materials, either in motion or fixed. (10-101)

Control Instruments

Brown "Air-o-Line" (air-operated) controllers are discussed, and typical installations illustrated in a new bulletin of Brown Instrument Co. (10-17)

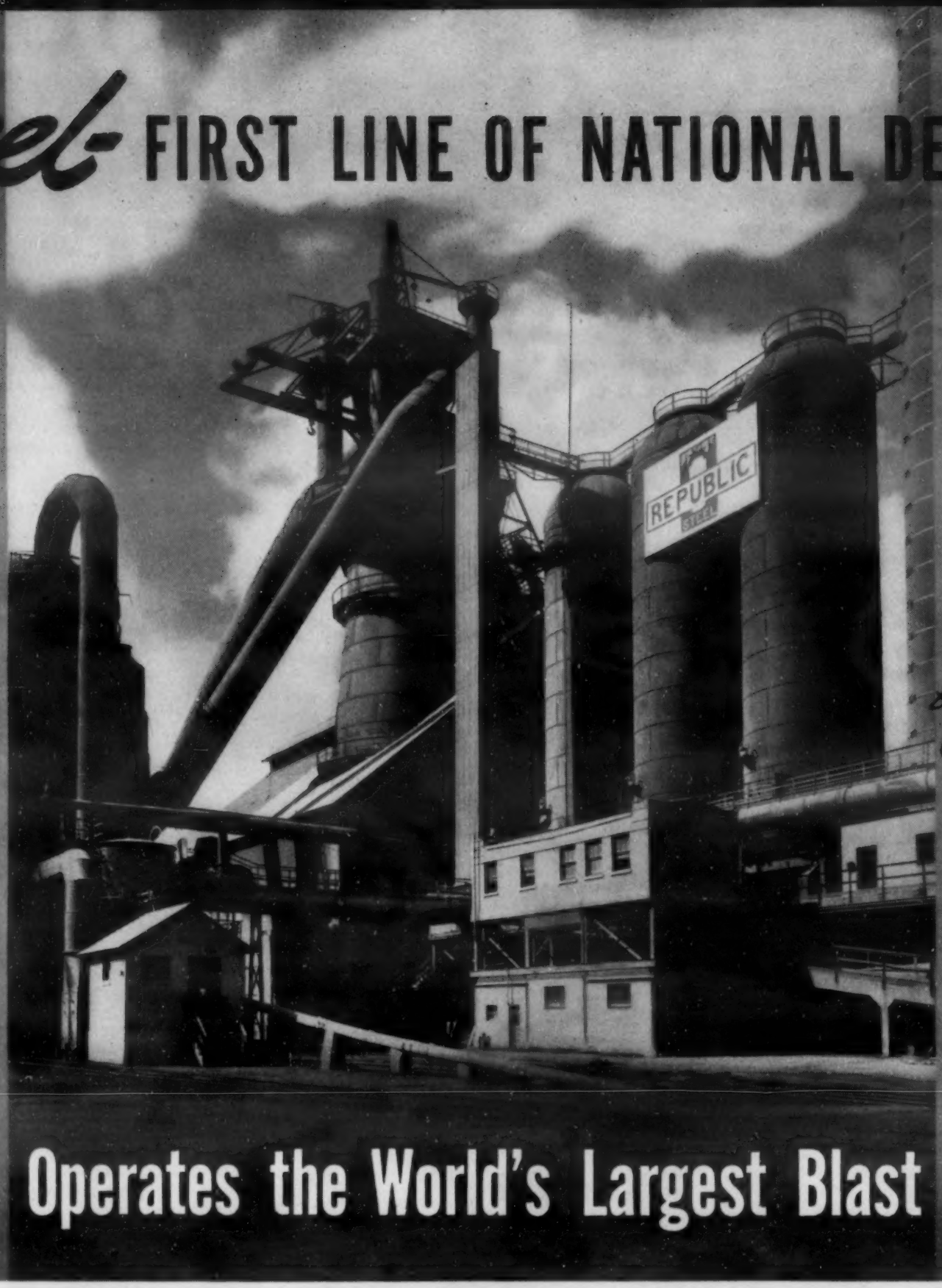
Metallographic Polishing Equipment

The new Jarrett metallographic polishing machine, said to be almost completely automatic, and the Jarrett specimen mounting press are described in literature of Tracy C. Jarrett. (10-117)

Salt Spray Test Containers

The unique advantages of long-lived, compact Alberene stone containers for salt spray corrosion testing equipment are presented in literature of Alberene Stone Corp. of Va. (10-120)

Steel- FIRST LINE OF NATIONAL DEFENSE



Republic Operates the World's Largest Blast Furnace

Every day more than one thousand tons of iron pours from this blast furnace—the largest in the world.

Add to this the output of sixteen other furnaces and you have a vivid picture of Republic's capacity to produce huge quantities of pig iron—the basic material from which all steels are made.

Compared with ten years ago, Republic's blast furnace capacity has increased 40 per cent. Ore reserves too, have been expanded, as well as open hearth, electric furnace, rolling mill and finishing capacities.

Republic offers its entire facilities—men, materials, machines and morale—to the support of those industries upon which now falls the burden of maintaining America's freedom. Republic is ready with ***steel—first line of national defense.***

The line of steels and steel products manufactured by Republic is so diversified that we have prepared a complete listing in Booklet No. 199. A copy will be sent you upon request.

REPUBLIC STEEL CORPORATION • CLEVELAND, OHIO

Berger Manufacturing Division • Niles Steel Products Division • Steel and Tubes Division • Union Drawn Steel Division • Truscon Steel Company

PROGRESSIVE VISION

GUGLIELMO MARCONI

Since 1901 great systems of wireless, and later, radio communication have sprung from a faint signal of the call letter "S" that flashed seventeen hundred miles across the Atlantic, to mark the first successful effort to explore the field of electronic force.

Many improvements have come in rapid succession, but the principles differ very little from those established by Marconi nearly forty years ago.

The elements of space are now added to the march of progress.

THERMALLOY *the "EYE" of QUALITY*

THE ELECTRO ALLOYS COMPANY

CASTINGS FOR HEAT CORROSION

ELYRIA, OHIO

QUALITY CASTINGS SINCE 1919

Each one labelled to show strength and hardness...

CERTIFIED GEARS ★

...cast in NICKEL alloyed iron

DEPENDABILITY is all-important to the designing or specifying engineer when selecting a gear and no gear is more dependable than the material from which it is made.

Braun Certified Gears are dependable. Made of a Nickel-chromium-molybdenum cast iron each gear is tested, labelled and guaranteed to provide a minimum tensile strength of 50,000 p.s.i. High hardness controlled within narrow limits reduces abrasive wear, preserves tooth contours and assures longer service.

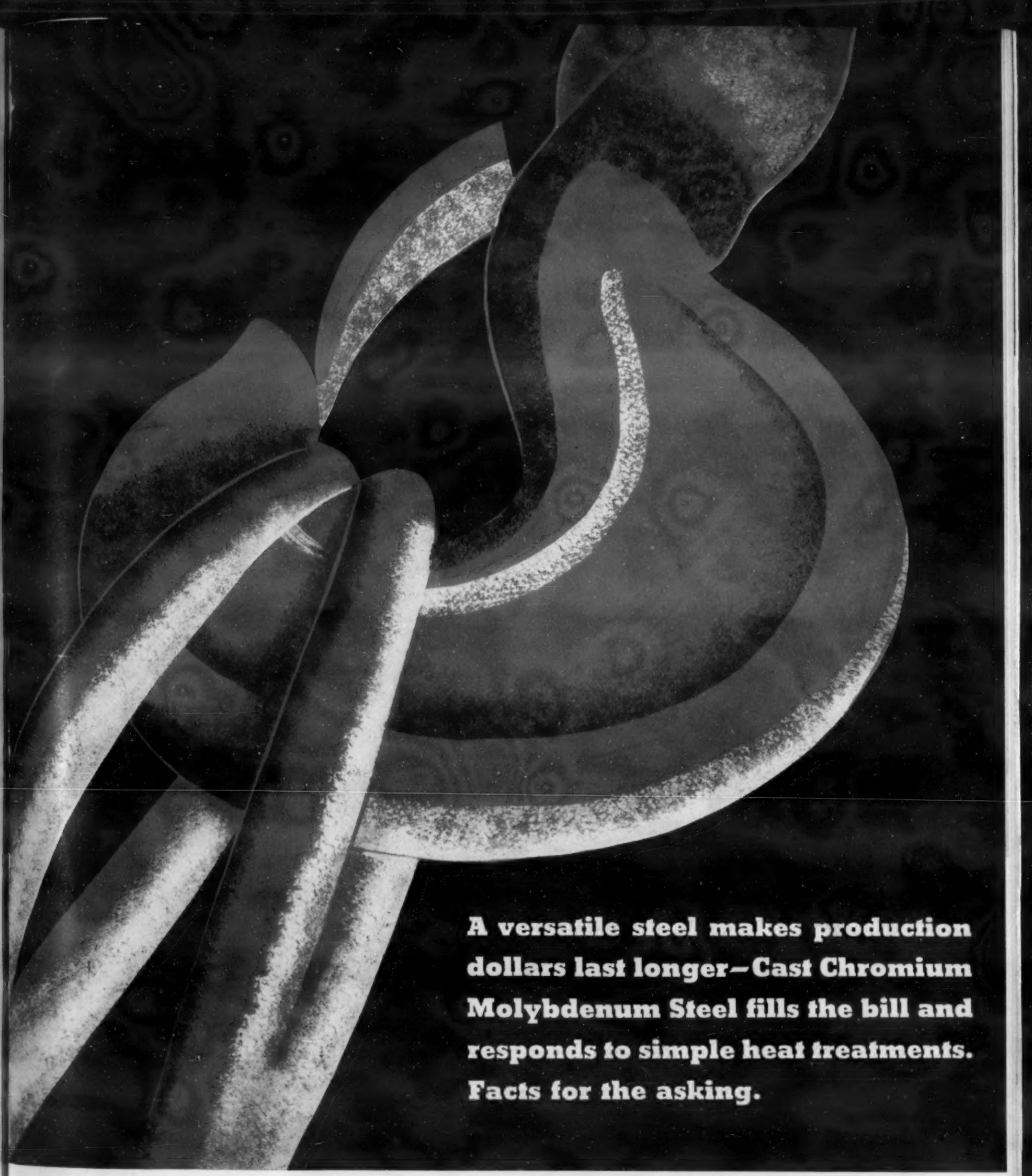
The improved properties of Nickel alloy cast irons enable Braun gears to more successfully withstand abnormal loadings and stresses. Furthermore the uniformly high strength of this material permits redesigning for smaller gears and more compact assemblies.

Consultation is invited on your problems involving Nickel.

Typical minimum properties of Nickel-chromium-molybdenum cast iron used by Braun Gear Corp.:

Minimum tensile strength, p.s.i.	50,000
Compression strength, p.s.i.	150,000
Shear strength, p.s.i.	58,000
Torsional strength, p.s.i.	67,000
Modulus of elasticity	20,000,000
Torsional modulus elasticity	7,500,000
Transverse strength, lbs.	3,000
Transverse deflection, in. (test bar 1.2" diameter, 18" span)	0.04
Brinell hardness	220
Weight per cubic inch, lbs.	0.26

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.



A versatile steel makes production dollars last longer—Cast Chromium Molybdenum Steel fills the bill and responds to simple heat treatments. Facts for the asking.

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

MEETING A THREE-WAY DEMAND

A large fruit juice extractor looks so simple that there would not appear to be any special problems in the selection of materials for its parts. Yet, the screw must stand high pressures, and tramp iron can cause serious trouble. Ripe fruit won't wait for machine repairs.

Because it meets all three demands of the service so well one manufacturer of extractors now uses nothing but cast Carbon-Molybdenum steel for the screws. The steel (1) develops the requisite strength and toughness when normalized; (2) is comparatively inexpensive and (3) permits easy reconditioning when it is finally required — the worn spots being built up by welding and re-machined to original dimensions.

Here, then, is another case where the use of modern materials has economically achieved a distinct product benefit. There may be similar opportunities in your own product. Our book, "Molybdenum in Steel", which is sent free on request will help you find them.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

Alarm bell manufactured by Edwards & Company, Norwalk, Conn., using Monel plunger and "Z" Nickel flat reaction spring.

Quick, faultless operation at critical time assured by heat-treated "Z" Nickel

No chances can the maker of this high quality alarm bell take in its manufacture. Used in schools, factories, hospitals and the like, it must respond without fail in emergencies.

Critical parts are the spring and plunger...which must remain free of rust and corrosion to insure good working condition even after long periods of inactivity. Also essential for the flat reaction type spring is absolute reliability as to length of life. Performance of some metals tested varied from the required 1000 continuous operating hours down to only two or three. "Z" Nickel*, however, was still operating perfectly after 1685 hours.

In addition, the plunger must not become upset by continual striking against the bell. Since Monel* combines corrosion resistance with the necessary toughness and hardness, it is the metal used for this important part.

Nickel base alloys are all strong, tough, rust proof and resistant to corrosion. Each offers special additional properties. Further information in "7 Minutes with 7 Metals." Write for this booklet today. Address:

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York, N.Y.

Mechanical Properties & Physical Constants of "Z" Nickel

Form and Temper	*Tensile Strength 1000 psi.*	*Elongation in 2 in. per cent.*	*Rockwell "C" Hardness*
SPRING TEMPER WIRE			
—as drawn	160-200	5-2	....
—heat treated	200-240	10-5	....
HALF HARD TEMPER STRIP			
—as rolled	130-155	15-3	25-34
—heat treated	160-210	20-7	33-42
FULL HARD TEMPER STRIP			
—as rolled	155-190	10-2	30-40
—heat treated	180-230	15-5	36-46

Density (lb. per cu. in.)	0.316
Electrical Resistivity (ohms/mil ft. at 32° F.)	95-100
Electrical Resistivity Temperature Coefficient (per ° F.)	0.002

"Z" NICKEL

*"Monel" and other trade-marks which have an asterisk associated with them are trade-marks of The International Nickel Company, Inc.

A TOUGH FAMILY

A group of high-Nickel alloys, each of which, like Monel, is strong, tough, immune to rust, and highly resistant to corrosion. Each offers other important characteristics peculiar to itself:

"K" MONEL: (66% Nickel, 29% Copper, 2.75% Aluminum) . . . strength and hardness comparable to the best alloy steels developed through heat treatment. Non-magnetic.

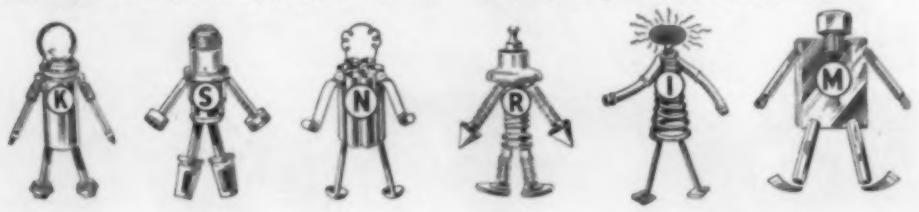
"S" MONEL: (in cast form only) . . . extra hard, non-galling and non-seizing, excellent mechanical properties and highly resistant to corrosion.

NICKEL: (99.4% pure . . . excellent heat transfer, wide use in processing pure products, exceptional resistance to caustic soda corrosion.

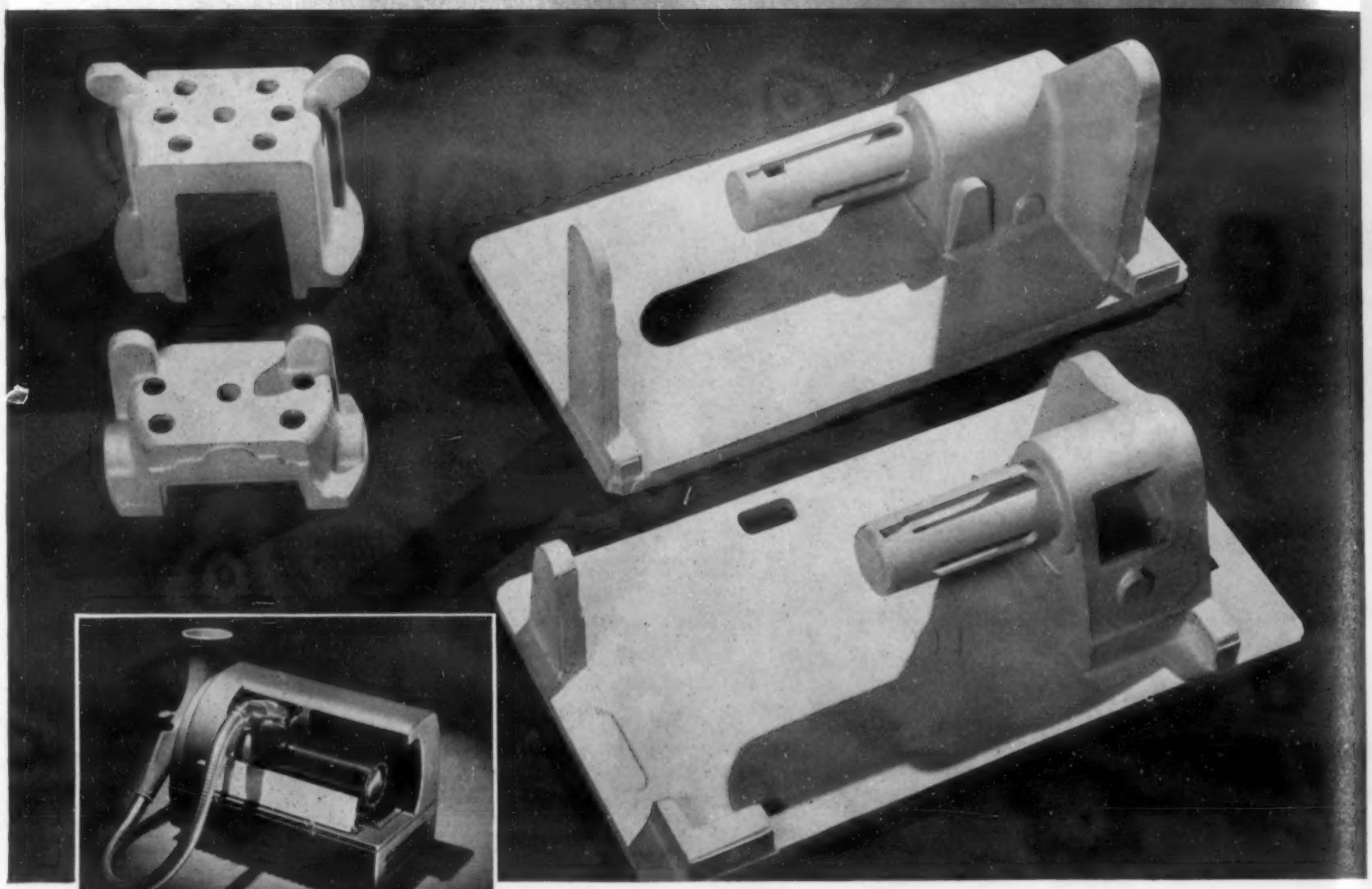
"R" MONEL: (67% Nickel, 30% Copper, .035% Sulfur) . . . free machining. Stronger and tougher than Bessemer screw stock.

INCONEL: (79% Nickel, 13% Chromium, 6% Iron) . . . Highly resistant to heat, oxidation, and embrittlement. Excellent corrosion resistance.

MONEL: (2/3 nickel, 1/3 copper) . . . Combines steel-like strength and toughness with immunity to rust and high resistance to corrosion.



SOMETHING FOR THE *Record*



Dictaphone's new Cameo dictating machine.

Dictaphone's dictating and transcribing machines first employed Aluminum sand castings to obtain compactness and light weight. Then, as production schedules called for larger quantities, the switch was made to Alcoa permanent-mold castings.

No changes in design were required. A few minor changes, however, enabled them to take advantage of the closer dimensional tolerances. And, within a year, the savings on machining and finishing thus obtained more than paid for the mold equipment.

It's easy to make the change to Alcoa Aluminum permanent-mold and semi-permanent-mold castings. You get high production at relatively low cost. You save on machining and finishing, because dimensional tolerances are close. The metal is sound and strong. Surfaces are smooth, taking a fine finish. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh, Penna.

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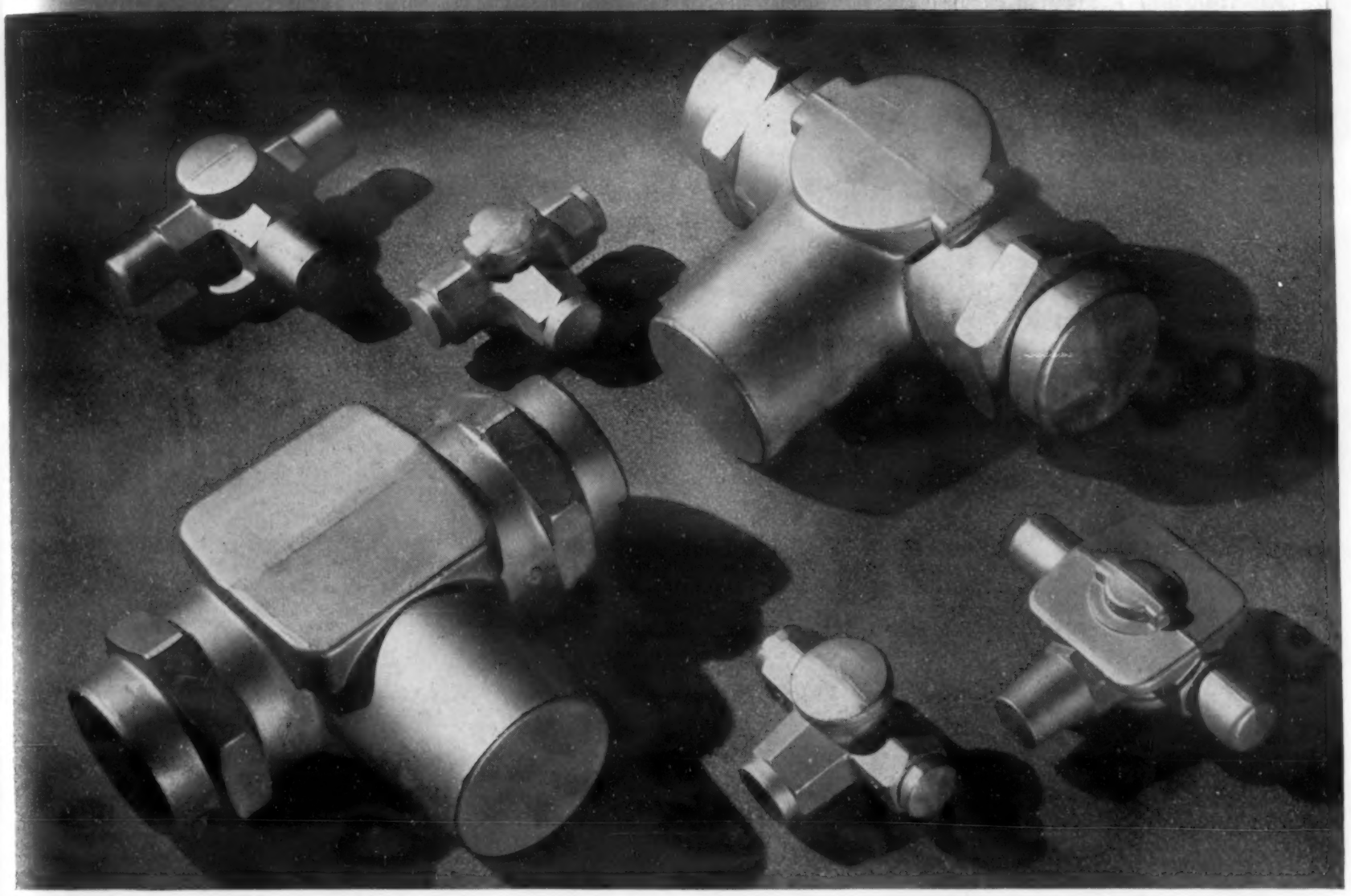

Press-forged valve bodies made for Parker Appliance Company.

The valves to be made from these blanks must be light in weight, pressure-tight and resistant to corrosion. Since the blanks were forged from an Aluminum Alloy, the valves will easily meet all three specifications. Alcoa press and hammer forgings have dense metal structure. They are uniformly sound and strong.

These valves will have the same long life and freedom from harmful action as the Aluminum processing equipment with which they are used.

Alcoa Aluminum press forgings often make it possible to show sizable savings in manufacturing costs. Shapes can be quite complicated and they are held to close dimensional tolerances. Small design detail and lettering can be accurately reproduced. Fewer finishing and assembly operations are required. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh, Pennsylvania.

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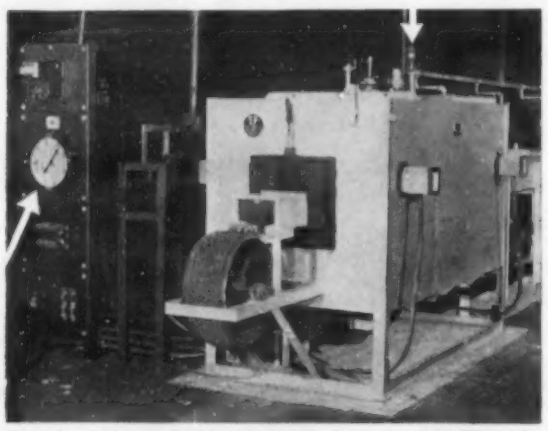
Brazing Furnaces Often Need "Rayotubes" To Hold Heat In Line

As those who use them know, controlled-atmosphere brazing furnaces can often do spectacular things in speeding up the assembly of metal articles. And it has been our privilege to have a hand in making some of these furnaces even more useful, by furnishing "Rayotubes" instead of ordinary thermocouples, for their temperature regulation.

The reason is that ordinary couples, in the "reducing" atmosphere of brazing, are apt to be unreliable. But a Rayotube, staring unwinkingly at the procession of white-hot parts, is not exposed to the furnace atmosphere. It stays outside the furnace, sealed against all gases. For that reason, it is continuously reliable for years and enables its Micromax Controller to do an outstanding job of temperature-regulation.



Brazing of automotive parts is done in this Electric Furnace Co. continuous belt-fed controlled-atmosphere unit. Arrows show Rayotube temperature detector and Micromax Recording Controlling pyrometer.

In the Electric Furnace Company unit shown here, for example, automotive parts are brazed together to form remote-control shift levers, clutch-release shafts, steering-knuckle-support arm brackets, and various other assemblies. Capacity is 250 lb per hr continuously; assemblies are joined about 60 per cent faster than by previous methods, and with about 75 per cent less labor. Performance is such that a second furnace of the same type and with the same Rayotube-Micromax control has been ordered.

Control To 5 Degrees

Temperature is set at 2050 F, and is actually held there to within plus or minus five degrees. Such close control would of course hardly be possible without uniform and careful loading of the furnace, but it would also be impossible without pyrometer equipment which can be relied on to hold its accuracy and responsiveness.

The same advantages which make the Rayotube-Micromax combination so effective for controlled-atmosphere furnaces also cause it to be used on a great variety of other furnaces where, for one reason or another, thermocouples are not satisfactory. If your plant has such a problem, we'll be glad to discuss it with you. In writing also ask for Broadside N-33 which gives a general idea of the types of instruments available.

General views of new heat-treating department, The Hale Fire Pump Co., Inc., Conshohocken, Pa., and close-up of wo

Rejection-Free HEAT-TREATMENT

When Gears Are Homo Carburized & Tempered

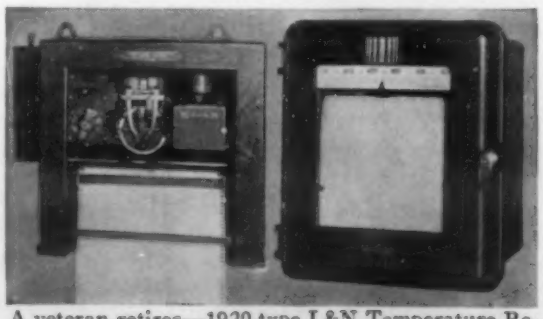
Heat-treating of gears for pumping engines was very noticeably improved by The Hale Fire Pump Co., Inc., when they started using a Homocarb furnace for hardening and a Homo furnace for tempering. These furnaces were brand-new to the Hale heat-treaters, but they enabled the men to apply their knowledge and skill, so that better results than ever before are being attained.

Specifically, hardness of gears is up 6 to 8 scleroscope points; uniformity of hardness is excellent and wearing qualities are substantially increased. Scaling, pitting and soft spots are entirely eliminated, and distortion is negligible, so that refinishing costs are considerably reduced.

And, if The Hale Company decides to carburize instead of harden, their Homocarb and Homo will continue to give them the same rejection-free heat-treatment. Uniform heating, uniform atmosphere, and convenient, fully-automatic operation make these furnaces ideal for either heat-treat operation.

If you have a heat-treatment problem involving furnaces, send us specific information or write for catalogs.

A "First" Potentiometer And Its Micromax Successor



A veteran retires—1920-type L&N Temperature Recorder and its replacement, a Micromax Pyrometer

Pyrometric control was just beginning to "get its growth" in the metal industries when the L&N Potentiometer Pyrometer shown here was built. It went, in 1920, to the Standard Steel Works Co., Burnham, Pa., now a division of Baldwin Locomotive Works.

From its worn condition, we gather this pyrometer delivered full service. And yet, it could go right back to work, if we still had replacements for a few of its parts. And the Micromax Pyrometers we supply today are even more dependable than this veteran, because the things we learn from instruments like this are applied in Micromax.

Its five models are described in Catalog N-33A.

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Foreword by C. A. Browne,
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Of even greater interest than the text is the wealth of illustrations, which are highly interesting and of real antiquarian value. They include pictures of medieval equipment, original apparatus designs and unique experiments, as well as of pioneers in chemistry. The attractiveness of the book is increased by hand-color plates. This collection of pictures alone will be of surpassing interest to all chemists and equipment manufacturers.

Ernest Child has devoted many years of painstaking research to the production of this volume. Long associated with manufacturers and dealers in chemical equipment in both Europe and America, he has had the opportunity to visit leading educational and industrial laboratories and to obtain through his many contacts the outline of this valuable history. His own perseverance in tracking down details has enabled him to fill in this outline, and make it a connected whole. The result of his efforts will be applauded by the entire chemical profession.

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of Metals & Alloys, published monthly at East Stroudsburg, Pa., for October 1, 1940.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Philip H. Hubbard, who, having been duly sworn according to law, deposes and says that he is the Publishing Director of Metals & Alloys and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

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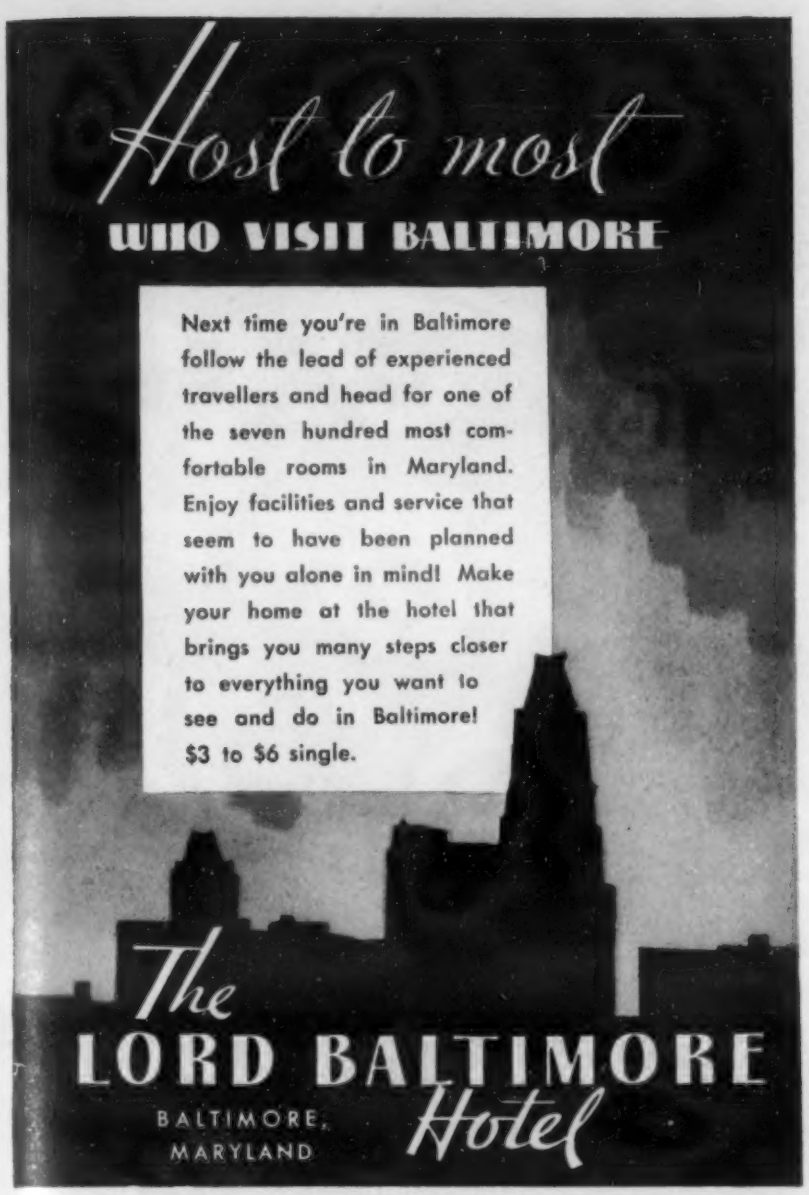
(My commission expires March 30, 1942.)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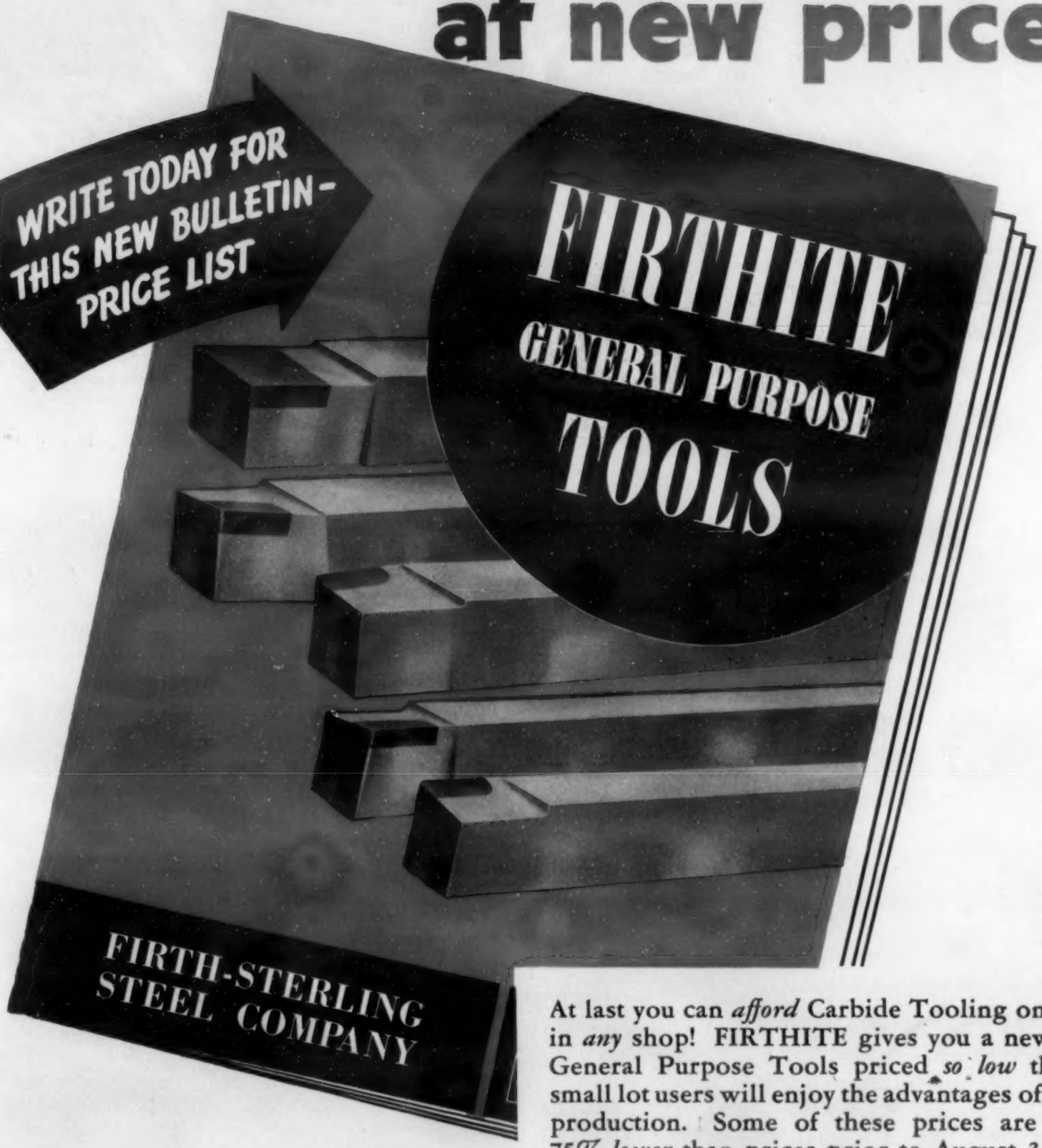

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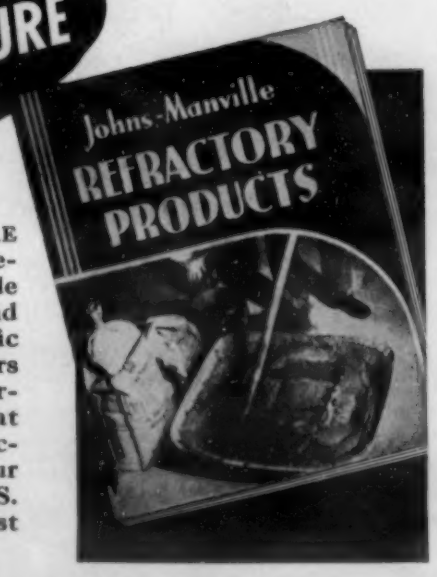

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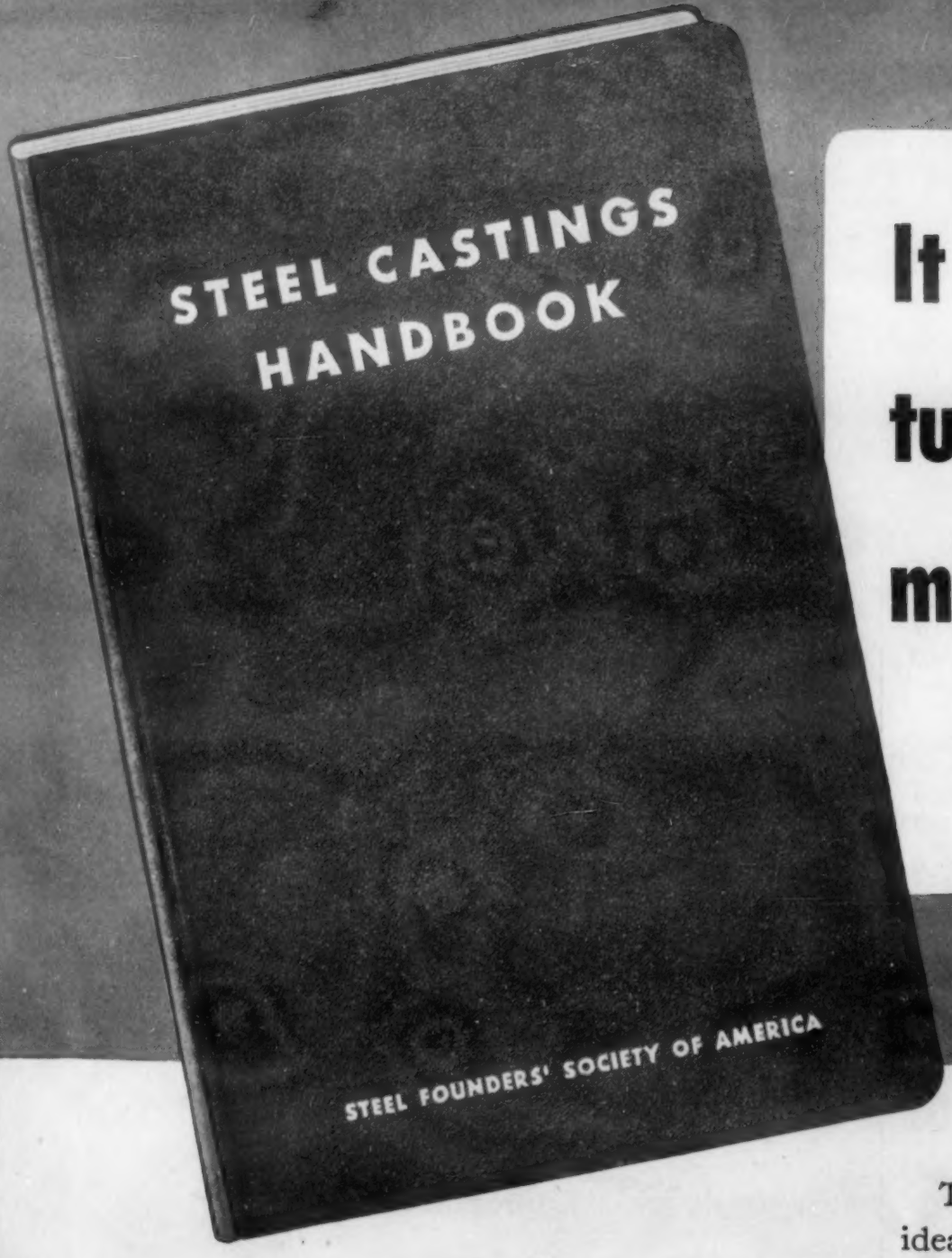

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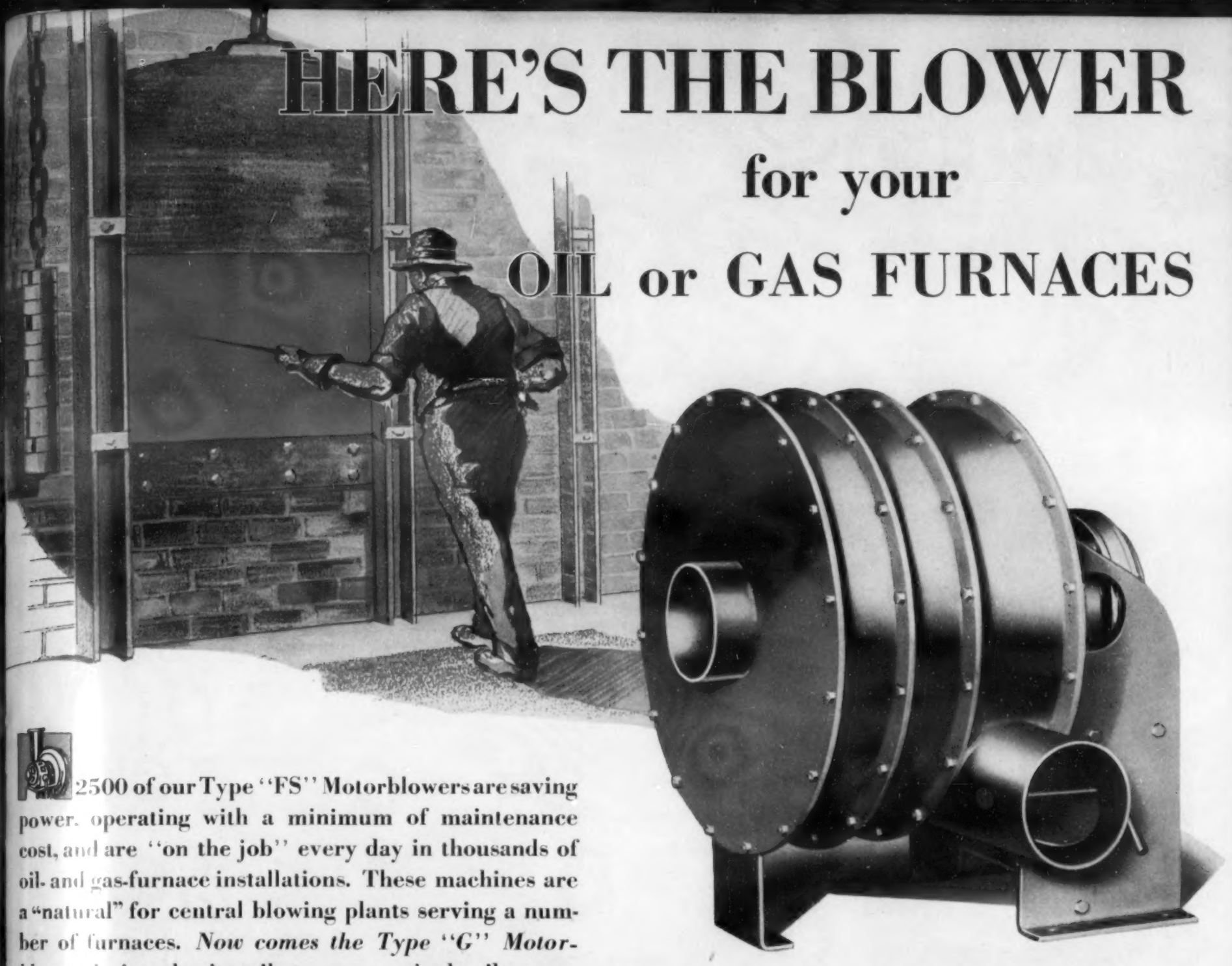

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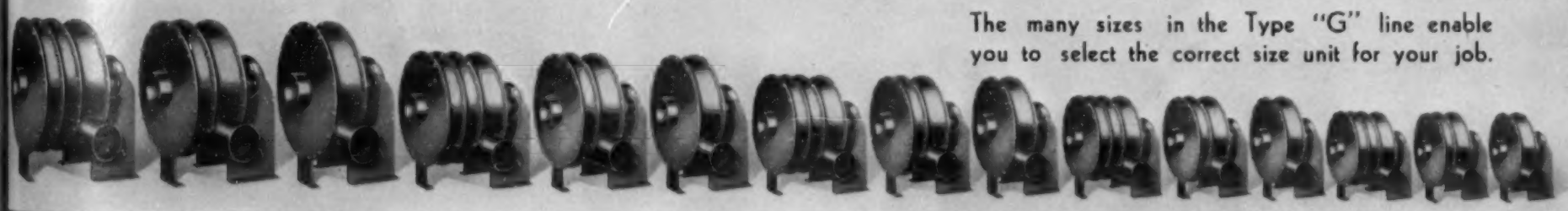

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Ryerson & Son, Inc., Joseph T. 614

St. Joseph Lead Company 666
Agency—Frank Best & Company, Inc

Scomet Engineering Company 697

Scott Company, Henry L. 702
Agency—Richard Thorndike

Spencer Turbine Company 665
Agency—W. L. Towne

Steel Founders' Society 694
Agency—Fuller & Smith & Ross, Inc.

Taylor Sons Company, Charles 672
Agency—Strauchen & McKim

Tennessee Coal, Iron & Railroad Company 596, 597
Agency—Batten, Barton, Durstine & Osborn, Inc.

Thermal Syndicate, Ltd. 702

Timken Roller Bearing Company, Steel & Tube Division 703

Titanium Alloy Manufacturing Company 663
Agency—Addison Vars, Inc.

Union Carbide and Carbon Corporation 601

United States Steel Corporation 596, 597, 697
Agency—Batten, Barton, Durstine & Osborn, Inc.

United States Steel Export Company 596, 597, 697
Agency—Batten, Barton, Durstine & Osborn, Inc.

Wilson Company, H. A. 693
Agency—Chas. Dallas Reach Company

Wilson Mechanical Instrument Company 700

ADVERTISING OFFICE: 330 W. 42nd St., New York, N. Y.

Philip H. Hubbard, Publishing Director, Wm. P. Winsor, Business Manager.

Frank J. Enright, Advertising Manager, 1133 Leader Bldg., Cleveland, Ohio.

HUGHES PRINTING CO.
EAST STROUDSBURG, PA.
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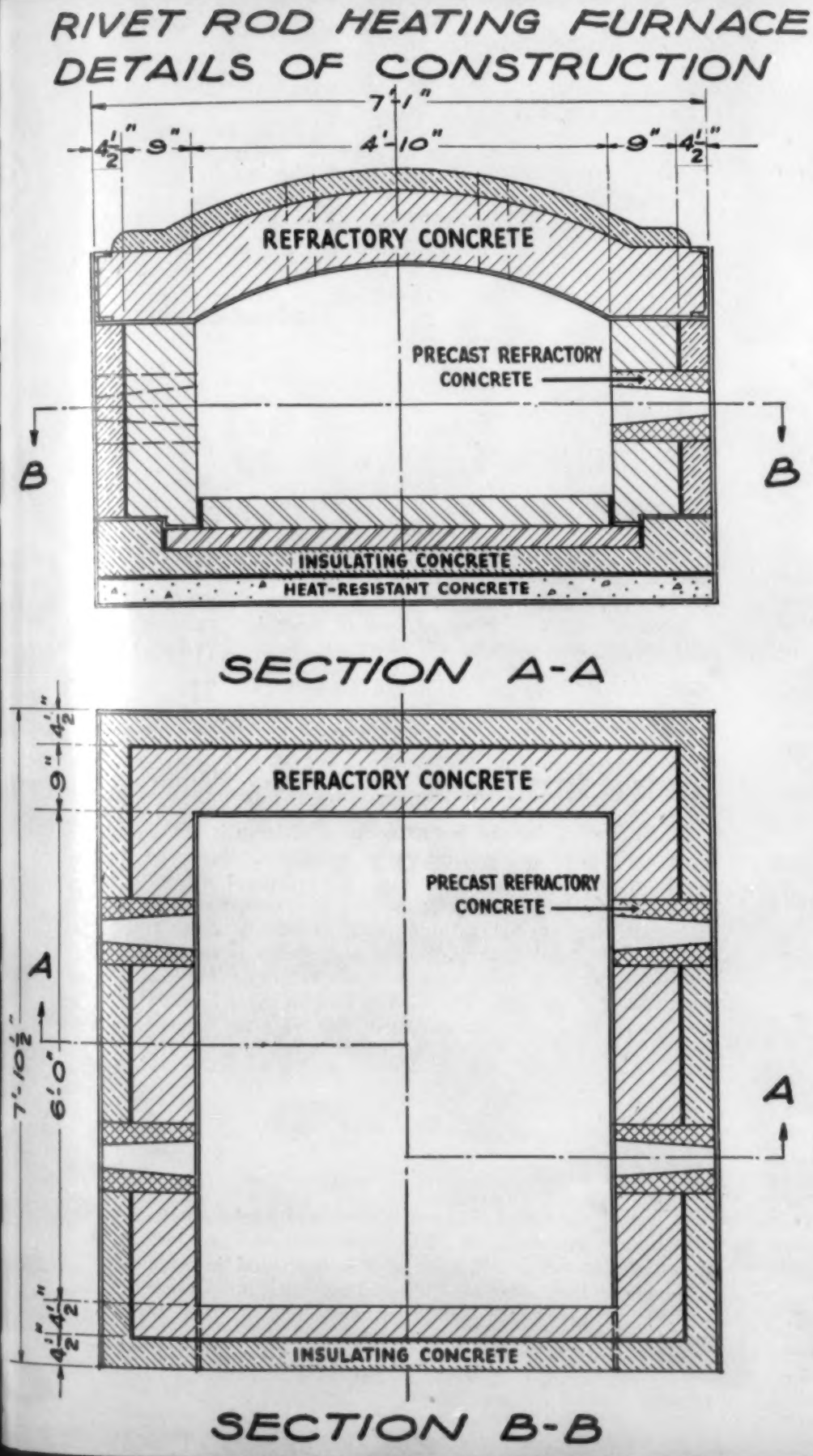
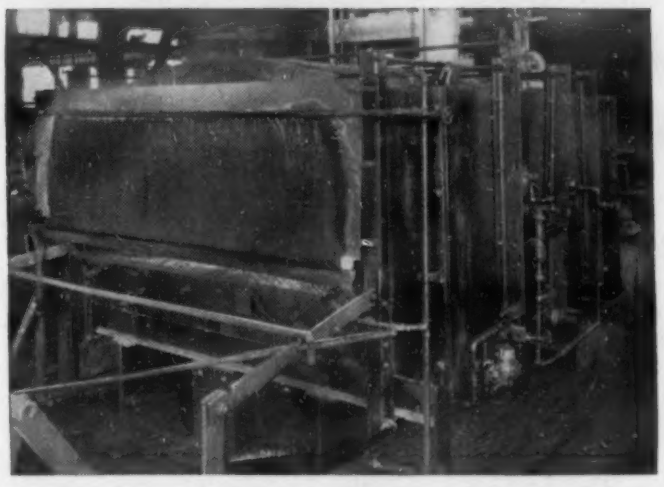
How they built this furnace with 3 KINDS OF CONCRETE

The Dominion Bridge Co., Ltd., of Lachine, Quebec, did a complete job in this furnace with Refractory Concrete, Insulating Concrete and Heat-Resistant Concrete—all made with LUMNITE





ADAPTABILITY to a variety of high temperature conditions led to the use of three kinds of LUMNITE concrete in building this rivet-rod heating furnace.

- **Refractory Concrete construction eliminated joints, cut down air infiltration, thereby reducing scaling to a minimum and saving heat.**
- **Insulating Concrete back-up, sub-floor and roof cover further reduced heat loss and smoothed out temperature control.**
- **Heat-Resistant Concrete formed a level, monolithic bottom slab.**

All three concretes—Refractory, Insulating and Heat-Resistant—were made with LUMNITE, a cold-setting, rapid-hardening binder. Cast-in-place Refractory Concrete and Insulating Concrete form the bottom, walls and roof arch. Burner ports are precast Refractory Concrete units.

The desired refractory and insulating properties of each kind of concrete are determined by the type of aggregate. LUMNITE is the binder holding the aggregate together to form concrete which will stand up at high temperatures. The Dominion Bridge Company used crushed fire brick and LUMNITE for the Refractory Concrete, a lightweight insulating aggregate and LUMNITE for the Insulating Concrete.

Keep LUMNITE in stock. With a supply of inexpensive aggregates you will have material on hand for a great variety of refractory installations—and for speedy repairs.

For detailed information, write for booklet, "Refractory Concrete." Address Atlas LUMNITE Cement Co. (United States Steel Corporation Subsidiary), Dept. M-4, Chrysler Building, New York City.

LUMNITE FOR REFRACTORY CONCRETE

trends

By Edwin F. Cone, Editor

Higher Non-Ferrous Earnings

Earnings of non-ferrous companies made drastic increase during the first half of this year. "Ten leading non-ferrous companies, who issue quarterly earnings, had an average gain of 27 per cent in the second quarter of 1940 as compared with the first quarter; a gain of over 55 per cent was registered by the 20 leading producers when comparing the first half of 1940 with the first half of 1939."

Secondary Non-Ferrous Metals

That the secondary non-ferrous metal industry is by no means a small one is demonstrated by the fact that data of the U. S. Bureau of Mines, recently issued, showed that in 1939 the value of the secondary aluminum, antimony, copper, lead, nickel, tin and zinc, recovered as metal and in alloys and chemical products, amounted to $199,856,800. Of this, metals recovered from new scrap (materials produced as a result of manufacturing operations) were valued at $81,-868,200 and metals recovered from old scrap (materials returned from use) at $117,988,600.

Stainless Steel for Airplanes

According to a published statement of the International Nickel Co., "the stainless steels of the 18 and 8 and higher alloy type are witnessing a marked increase in tonnage. A recent estimate gives the amount of stainless steel used thus far in 1940 (September) by West Coast airplane makers for non-structural parts alone at 2,000,000 lbs."

New and improved methods for bonding stainless steel to carbon steels are arousing wide interest in clad materials, this same authority states.

Pig Iron Exports

The trend in the foreign demand for American pig iron is decidedly upward this year. To Aug. 1, according to official Government data, over 201,700 gross tons had been exported as compared with only 33,950 tons to Aug. 1, 1939.

Desulphurizing Hot Metal

A new trend in research is the rather ambitious plan of the blast furnace and raw materials division of the A.I.M.E. It is a large scale practical investigation into the use of alkali for the external desulphurization of hot metal from the blast furnace. It is being conducted at the Monessen, Pa., plant of the Pittsburgh Steel Co. It is the belief in some quarters that the experiment will develop a practice which will provide increased tonnage at lower cost and of lower sulphur content. To collect and properly correlate the data will consume considerable time and finally a paper will be prepared to publicize the results. It is similar to the process used at Corby, England.

Tin Plate Exports

Foreign shipments of American tinplate and taggers tin have increased decidedly as a result of the war. Of the 305,-525 gross tons exported in 1939, more than one-third or 104,262 tons was shipped in November and December. To Aug. 1, this year, this volume had increased to over 42,000 tons per month. This trend is due to the fact that European countries have had to curtail exports because of the war. In 1939, Brazil was the largest customer with the Netherlands second and Canada third.

Steel Exports Expand

Exports of American steel are rapidly expanding. According to a statement of the Department of Commerce, the total outgo in July at 707,809 gross tons, exclusive of scrap, reached the highest level in many years. They were 80 per cent above the April exports of 391,754 tons.

Seven months cumulative exports at 3,478,423 tons are over 200,000 tons in excess of three times the total (1,086,-873) for the same 7 mos. in 1939.

Exports of Scrap

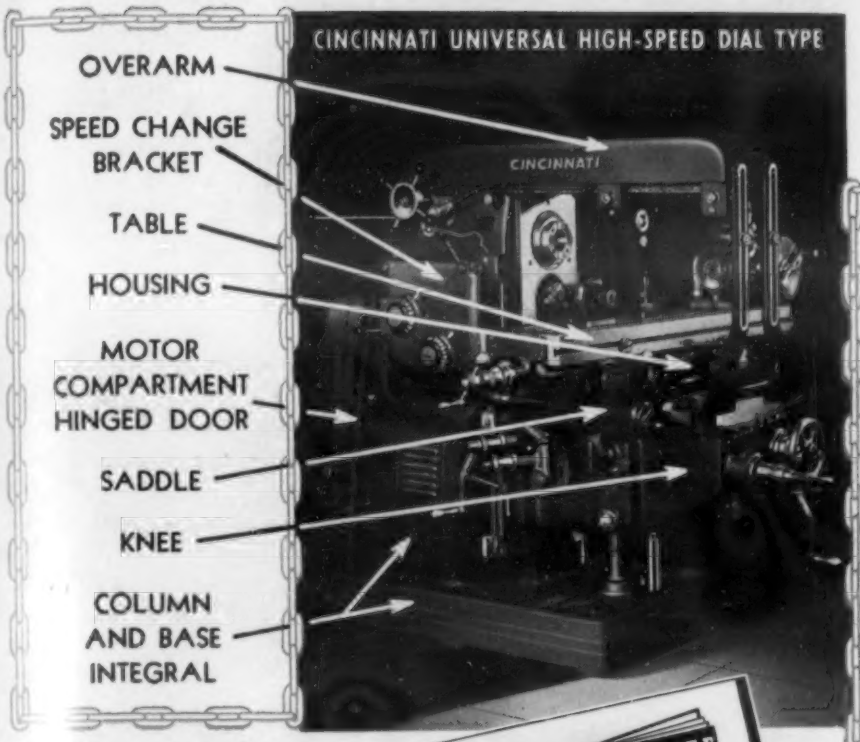
While foreign demand for American steel scrap is not as heavy as in 1939 and in some earlier years, it is increasing this year. The total outgo to Aug. 1 has been 1,808,234 gross tons or 258,300 tons per month. This compares with 2,139,018 tons or 305,600 tons each month to Aug. 1, 1939. Of the total to Aug. 1, this year, Japan is credited with only 529,092 tons against 1,161,530 tons for the same 7 mos. a year ago. For the first time in many months, the United Kingdom exceeds Japan this year at 599,814 tons.

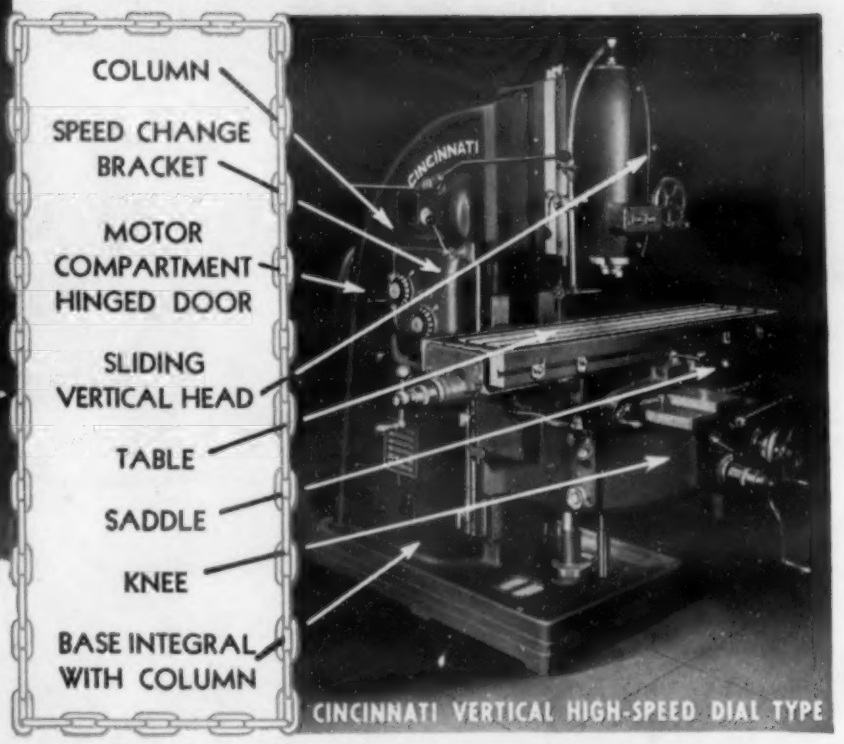
Imports of Steel

As is to be expected, imports of iron and steel into the United States are declining. The Department of Commerce states that for the first 7 mos. of this year total imports, including pig iron and ferroalloys and excluding scrap, were only 42,178 gross tons compared with 189,707 tons to Aug. 1, 1939.

(Other "Trends" on page 714)

In a CINCINNATI—
they're MEEHANITE
Castings throughout





Write for our NEW edition of Bulletin No. 9. It tells all about Meehanite Machine Tool Castings.

There is an old and true saying about a chain being only as strong as its weakest link. Today's machines and machine tools can afford no "weakest link." The castings with which they are built must give *positive* assurance of quality and service.

Proper strength and safety factor, vibration damping qualities, freedom from distorting strains,—all these plus the important property of good anti-friction must be obtained regularly and surely. The constitutional control of the Meehanite process assures correct structure and desired properties. That's why, in these *Cincinnati* Dial Type Milling Machines all iron castings are MEEHANITE.

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Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
Irvington, N. J.	Barnett Foundry & Machine Co.
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Mt. Vernon, Ohio, Grove City, Pa.	Cooper-Bessemer Corporation
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Oakland, Calif.	Vulcan Foundry Company
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St. Louis, Mo.	Banner Iron Works
St. Paul, Minn.	Valley Iron Works
London, Eng.	The International Meehanite Metal Co., Ltd.
Waterloo, N. S. W.	Australian Meehanite Metal Co., Ltd.

trends

By Edwin F. Cone, Editor

Ferroalloys

The trend in the output of ferroalloys by American furnaces has been definitely upward during the 18 months ended with June, 1940, according to data of the American Iron and Steel Institute. The output from both blast and electric furnaces for the first half of 1940 at 681,525 net tons is an increase of 77.3 per cent over the first half of 1939 and 40.9 per cent over the last half of last year.

The production of ferroalloys in blast furnaces, mostly ferromanganese and spiegeleisen, for the first half of this year at 494,567 net tons is an increase of 96 per cent over the same period in 1939 and of 47.7 per cent over the last half of last year.

Ferromanganese Supplies

The production of ferromanganese by American blast furnaces is probably at the highest rate this year since the World War of 1914 to 1918. According to the monthly blast data of *The Iron Age*, the output to Sept. 1 has been at the rate of 42,700 tons per month. This contrasts with only 18,600 tons per month for the first 7 mos. of 1939.

Supplies of Manganese Ore

Imports of manganese ore are mounting—a new record was made in August at 220,666 gross tons, all "for consumption." This trend is due to two causes, imports for Government stocks and imports to supply material for decidedly expanding ferromanganese production.

Pig Iron and Ferroalloy Output

Production of pig iron and ferroalloys by American furnaces, as was to be expected, shows for the first half of 1940 a marked increase—49.7 per cent—over the first half of 1939, according to the American Iron and Steel Institute. The total was 21,238,374 net tons. Rather unexpectedly this total is slightly less than the output for the last half of 1939 at 21,501,322 tons.

Electric Steel Capacity

The capacity of the American steel industry for making electric steel is rapidly being augmented. Press reports state that the Carnegie-Illinois Steel Corp. is building 2 new electric furnaces at its South Chicago plant increasing the corporation's electric steel capacity by about 100,000 tons a year.

Timken Roller Bearing Co., Canton, Ohio, has ordered a new 60-ton electric furnace for completion by Feb. 15, which will step up that company's monthly capacity to 25,000 tons.

Expansion of Republic Steel's capacity by several 50-ton furnaces was related in the article in our October issue—"Electric Furnaces and National Defense."

Steel Industry's By-Products

The value of the by-products of the steel industry is gradually mounting. The principal ones are gas, tar, crude light oils, and chemicals, obtained from the manufacture of coke for blast furnace fuel. The value of these products for 1939 was about $125,000,000 says the American Iron and Steel Institute. Part of the yield was consumed by the steel industry and the rest was marketed. In gas alone more than 510 billion cubic feet were produced, valued at $76,500,000. The 409,000,000 gallons of tar had a value of over $19,600,000.

Foreign Demand for Steel Ingots

Despite the war, the demand for American steel ingots, billets and blooms is definitely on the increase. Exports not containing alloys had amounted to 893,982 gross tons to Aug. 1, this year, contrasted with only 58,836 tons for the same period in 1939. Alloy-containing ingots, etc. (stainless included) this year were 22,980 tons as against only 6,616 tons last year for the first 7 mos.

Tungsten

According to Federal Loan Administrator Jesse H. Jones (also Sec. of Commerce!) the Metals Reserve Corp. has agreed to buy from the National Resources Commission of China $30,000,000 worth of tungsten. Delivery is arranged over a period of years. Thus our supplies should be adequate unless spread of the war should interfere.

Ni-Cr-Mo Steel

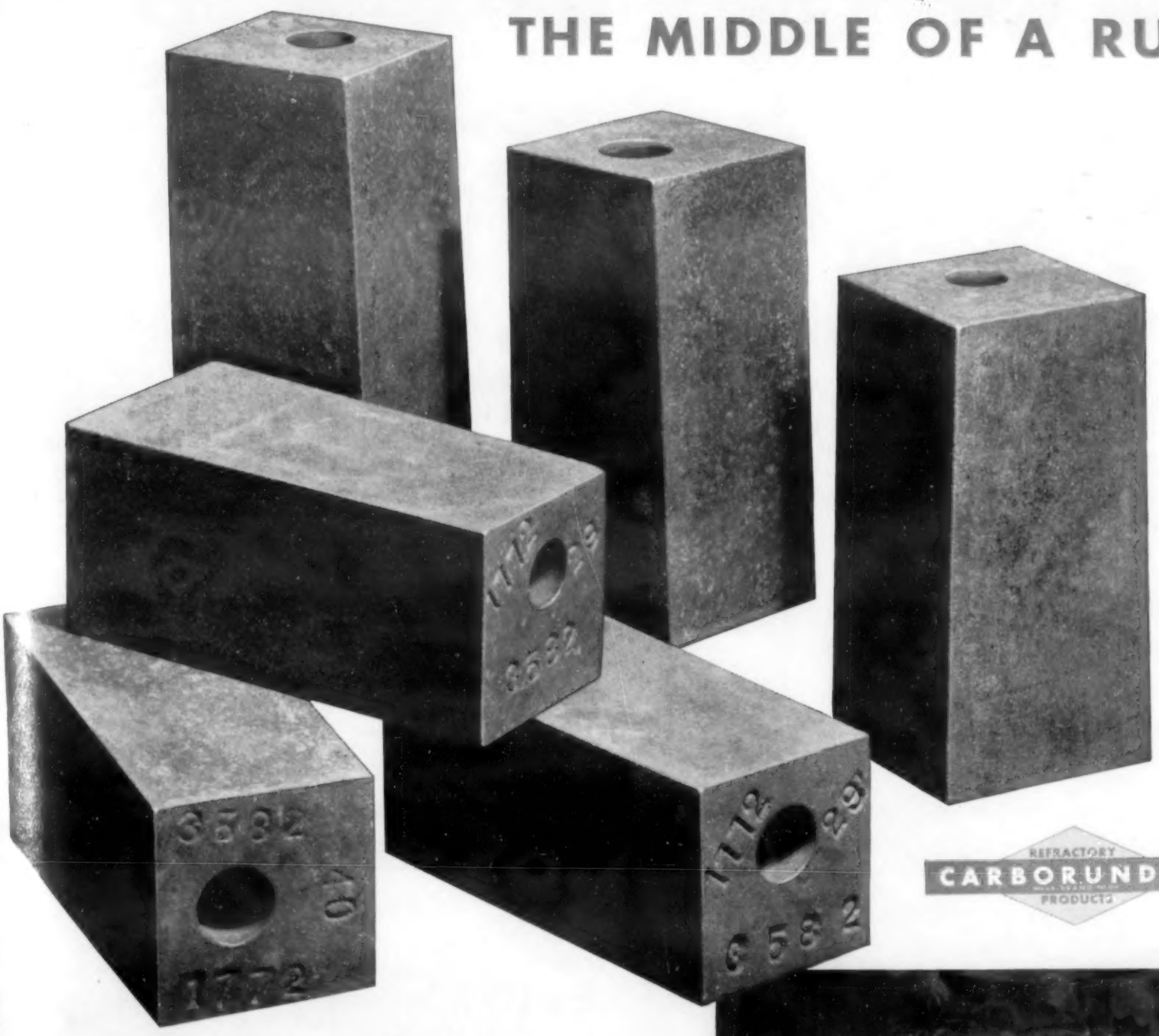
More Ni-Cr-Mo steel is being adopted for stressed parts in automotive and aviation production—parts which are subject to intricate machining. We are told that these steels are machined after heat treatment to 450 Brinell, once considered impractical.

Nickel Steel for Chemical Industries

Large quantities of 5 per cent Ni steel tubing have been installed in black liquor evaporators in paper mills, it is authoritatively stated. This is said to reflect an increased interest in steels containing 3.50 to 5 per cent Ni in the chemical and process industries.

(Additional "Trends" on page 712)

What! NO SLAG HOLE FAILURES IN THE MIDDLE OF A RUN?



REFRACTORY CARBORUNDUM PRODUCTS

● That's right—no failures, when you use "Carbofrax" slag hole blocks.

Ten hours, fourteen hours, even eighteen hours of continuous uninterrupted cupola operation is now possible with these super-refractory blocks made from "Carbofrax"—the Carborundum Brand Silicon Carbide Refractory.

No delays—no shutting off the blast—no slowing down—no added labor expense.

"Carbofrax" blocks have extremely high refractoriness. They are produced by a special process that gives a uniformly dense, durable structure so highly resistant to the abrasive action under the high temperature of molten slag that they maintain their hole size longer.

And don't forget that Carborundum also produces "Ferrocarbo" (deoxidizer and graphitizer for grey iron)—crucible and open flame non-ferrous furnace linings—furnace lids—refractory cement—and pyrometer tubes.

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(Carborundum, Carbofrax and Ferrocarbo are registered trade-marks of and indicate manufacture by The Carborundum Company)

How CRUCIBLE STEEL COMPANY USES AJAX-NORTHRUP FURNACES

Crucible Steel Company of America uses nine AJAX-NORTHRUP Induction Furnaces with melting capacities ranging from 50 to 2000 lbs. and located in their three principal plants. The illustrations above show three furnaces used for the production of stainless and other types of alloy steels, at their Harrison, N. J. Plant.

The capacities are 50, 300 and 2000 lbs. per melt. All three are operated alternately for the quantity production of alloys, and the 50 and 300 lb. furnaces are used for the production of ALNICO.

The advantages are as follows:

Uniform distribution of alloys in melt, particularly aluminum.

Rapid melting and solution of Alnico, thereby decreasing losses by oxidation.

Control of temperature.

Ability to reclaim alloys with minimum loss, particularly Alnico.

Ability to pour direct from the furnace into the molds, thereby keeping gas absorption of the metal to a minimum.

AJ 33D

For Melting
•
Surface Hardening
•
Heating
•
Continuous Heat Treating

Ajax-Northrup Furnaces have pioneered in the production of many of our new alloys requiring high temperatures, and are now revolutionizing straight line production in forging, upsetting, surface hardening, heat treating and brazing operations.

ASK FOR THE AJAX-NORTHRUP BULLETINS

AJAX-NORTHRUP MELTING FURNACE CAPACITIES: ONE OUNCE TO EIGHT TONS

AJAX ELECTROTHERMIC CORPORATION

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AJAX ELECTRIC FURNACE CORPORATION, *Ajax-Wyatt Induction Furnaces for melting.*
AJAX ELECTRIC CO., Inc., *Ajax-Hultgren Salt Bath Furnaces and Resistance Type Electric Furnaces*